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1895.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

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An Enumeration of the *Dipterocarpaceæ*, based chiefly upon the Specimens preserved at the Royal Herbarium and Museum, Kew, and the British Museum; with Remarks on the Genera and Species. By Sir Dietrich Brandis, K.C.I.E., F.R.S., F.L.S.

[Read 6th December, 1894.]

(Plates I.–III.)

In the well-known work 'Verhandelingen over de Natuurlijke Geschiedenis,' the Botanical part of which was published at Leiden, 1839–42, Korthals gave the number of Dipterocarps known at that time as 34, viz. 23 species previously known, and 11 new species described by him in that work. 28 years later, in the 16th volume of the 'Prodromus' (1868), A. DeCandolle enumerated 126 species; Thiselton Dyer, in Hooker's 'Flora of British India' (1874), estimated the order at 170; and now, 20 years afterwards, there are 325 species, most of which I consider well established. These figures show the rapid increase which during the last 54 years has taken place in our knowledge of this difficult and interesting order. Dipterocarps as a rule are tall trees, and it is not easy to obtain complete specimens. Considering our, as yet, imperfect knowledge of the vegetation on the Philippine Islands, on large portions of Borneo, of Siam, and New Guinea, it seems not unreasonable to suppose that one half, or at the outside two-thirds, only of the existing

species are at present known to us. Under these circumstances any attempt at a new arrangement of the order must be regarded as provisional. Nevertheless such an attempt may be useful, in clearing the ground and in drawing attention to those characters which are of special importance in the systematic treatment of this order.

The above figures do not include *Ancistrocladus*, which forms a separate order (Engler, Natürl. Pflanzenfam. iii. 6. p. 274), nor *Lophira*, which E. Gilg has justly transferred to *Ochnaceæ* (*ibidem*, p. 143), nor do they include the African genus *Monotse*, the position of which in the system is doubtful. In regard to *Monotes*, reference is requested to what I have said regarding it in Engler's Nat. Pflanzenfam. iii. 6. p. 273.

Dr. Heim has in his 'Recherches sur les Diptérocarpacées' (Paris, 1892) established 30 genera in 8 series and 2 subseries. The 'Monographie générale de la famille,' promised on page 182, has not yet appeared.

Giving due weight to all characters, anatomical as well as morphological, the safest plan at the present time seems to be, to make 5 tribus and 16 genera. In the following summary the external morphological characters only have been entered.

I. Dipterocarpeæ.—A limited number of very prominent secondary nerves; calyx-tube enclosing the fruit; 2 lobes expanding into long wings. Stamens more than 20; connective prolonged into a long point. Ovary with a large fleshy stylopodium.

Stipules large, amplexicaul; calyx-tube free; stamens ∞ ; style filiform .... 1. *Dipterocarpus.*

Stipules small, deciduous; fruit connate with calyx-tube; stamens 20–35; style short .... 2. *Anisoptera.*

II. Dryobalanopseæ.—Stipules small, caducous; secondary nerves very numerous, not prominent; stamens ∞ ; connective with a short point. No stylopodium. Base of fruit enclosed in a short cup-shaped calyx-tube, the segments of which are equal (generally long) wings; pericarp splitting into three valves. 3. *Dryobalanops.*

III. Shoreæ.—Calyx as a rule imbricate in bud, the 2 or 3 outer lobes accrescent in fruit, forming long wings; rarely the 3 lobes equal, onger or shorter than fruit. Stamens mostly 15, rarely more, in a few cases 10. Connective mostly awned.

3 wings; appendix of connective short, clavate; no stylopodium .... 4. *Doona.*

2 wings; appendix of connective long, pointed; as a rule a large stylopodium.	5. *Hopea.*
3 wings; anthers with 5 pointed appendages	6. *Pentacme.*
3 wings; appendix of connective as a rule long, pointed; stamens generally 15, sometimes more. Cotyledons thick, fleshy, folded in two along the midrib, or radicle lying between the 4 prismatic lobes of the cotyledons........	7. *Shorea.*
5 wings; calyx in bud nearly valvate; anthers with 3 short appendages......	8. *Parashorea.*
Lobes of fruiting-calyx shorter than fruit, round, unequal; stamens 30–36; appendix of connective ciliate; large stylopodium	9. *Isoptera.*
Lobes of fruiting-calyx equal, slightly enlarged, thick, and sometimes woody. Stamens 10 or 15; connective appendage long, pointed. Stylopodium distinct in most species	10. *Balanocarpus.*

IV. Vaticeæ.—Calyx valvate in bud; lobes generally equal in fruit, and not longer than fruit; in some cases 2 wings. Stamens 15. Anthers mostly short, oval. Appendage of connective short, generally obtuse. No prominent stylopodium.

2 wings; anthers oblong, hairy; appendix of connective pointed; cotyledons at the apex divided into numerous lobes..	11. *Cotylelobium.*
Lobes of fruiting-calyx equal; 2 wings in some cases; anthers short, oval, glabrous; appendage obtuse	12. *Vatica.*
Calyx connate with fruit; lobes equal; anthers of *Vatica*..................	13. *Pachynocarpus.*

V. Vaterieæ.—Calyx imbricate in bud. Lobes of fruiting-calyx equal and shorter than fruit. Stamens 5, 15, or ∞. Anthers linear-oblong, sessile or on short filaments. No stylopodium.

Anthers open at top, appendix short. Stamens 15; ovary 3-celled	14. *Stemonoporus.*
Same, but stamens 5; ovary generally 2-celled............................	15. *Monoporandra.*
Anthers open laterally; 1 or 2 appendages. Stamens ∞	16. *Vateria.*

As at present defined, Dipterocarps are only found in tropical Eastern Asia, from the Seychelles to New Guinea. A few species only occur beyond the tropics, viz.:—*Shorea robusta* to 32° N. lat.; *Dipterocarpus pilosus*, *Shorea assamica*, and *Vatica lanceæfolia* to 27° 30′ N. lat.; *Dipterocarpus turbinatus*, *tuberculatus*, and *Pentacme siamensis* to 25° N. lat.

The annexed statement (p. 5) shows distribution of the genera in the different districts. Species found in two districts are entered where they are most common. No species is entered twice.

H. Th. Geyler has published 5 species, chiefly based upon fragments of leaves, all from Borneo and Labuan, viz.: *Hopea præcursor*, *Dipterocarpus Pengaronensis* in 'Palæontographica,' 1877, and *Dipterocarpus Labuanus*, *Nordenskioldii*, and sp. in 'Vega Expedition,' vol. iv. 1887. It will suffice to say, that these fragments show no characters which necessitate their being placed in this order.

The only fossil remains which may safely be classed under *Dipterocarps* have been described by Heer, and they are:— *Dipterocarpus Verbeckianus*, Heer in Abhandl. d. Schweiz. Palæontolog. Gesellsch. 1874, tab. ii. fig. 3, and *Dipterocarpus antiquus*, Heer in Denkschr. allg. Schweiz. Gesellsch. für gesammt. Naturwiss. 1881, tab. v. Both are from the Tertiary deposits of Sumatra. *D. antiquus* was probably a species of *Shorea*.

The fossil remains, therefore, throw no light upon the development of this order. As regards its present distribution, the following facts merit special notice:—In the Eastern Peninsula of India and in the Indian Archipelago the order has received its greatest development, 115 species belonging to the former, 118 to the latter region. The large number of species in Ceylon, nearly all endemic (45), considering the comparatively small area of the island, is exceedingly remarkable. *Vaterieæ*, a well-marked tribus, entirely belongs to the Western districts, while the genus *Dryobalanops*, which in regard to external as well as anatomical characters occupies an exceptional position, is limited to the Eastern districts. As a rule the species of this order are limited to restricted areas, and a few species only have a wider distribution. Of these may be mentioned 4 species of *Dipterocarpus*, *Dryobalanops aromatica*, 3 species of *Shorea*, and *Isoptera borneensis*. Details will be found under each genus.

Most species have well-marked characters, and do not seem

	Seychelles.	Western Penins.	Ceylon.	Eastern Penins.*	Ind. Archip.†	Philippines.	New Guinea.	Total.
I. *Genera confined to the Western districts.*								
1. Doona	......	......	12	......	......	......	......	12
2. Stemonoporus	......	......	13	......	......	......	......	13
3. Monoporandra	......	......	2	......	......	......	......	2
4. Vateria	1	1	1	......	......	......	......	3
II. *Genera of wide distribution.*								
5. Dipterocarpus	......	2	5	27	22	8	......	64
6. Anisoptera	......	......	......	5	3	3	4	15
7. Hopea	......	4	3	13	23	2	1	46
8. Pentacme	......	......	......	2	......	1	......	3
9. Shorea	......	3	5	37	35	8	1	89
10. Parashorea	......	......	......	1	1	2	......	4
11. Balanocarpus	......	2	1	7	4	......	......	14
12. Cotylelobium	......	......	1	......	4	......	......	5
13. Vatica	......	1	2	21	18	1	2	45
14. Pachynocarpus	......	......	......	2	3	......	......	5
III. *Genera confined to the Eastern districts.*								
15. Dryobalanops	......	......	......	......	4	......	......	4
16. Isoptera	......	......	......	......	1	......	......	1
Total	1	13	45	115	118	25	8	325

* Comprises the trans-Gangetic Peninsula, including Assam and Chittagong.
† Borneo, Sumatra, Java, Celebes, and the smaller islands.

subject to much variation. Notable exceptions are the groups of *Dipterocarpus indicus* and *turbinatus*, of *D. alatus*, *costatus*, *ncanus*, and *scaber*, of *Shorea Talura*, *cochinchinensis*, and *floribunda*, and in *Vatica* (*Synaptea*), a group of trees found over the whole Eastern peninsula from Burma to Cochinchina, *V. Dyeri*, *grandiflora*, *faginea*, and *astrotricha*. Further researches may possibly prove the existence of two polymorphous species, one of *Dipterocarpus*, the other of *Vatica*, both with numerous local varieties.

Biological Features.

The most striking peculiarity of this order is, that numerous species are gregarious, forming nearly pure forests of large extent, in which one species has obtained the upper hand, to the exclusion almost of all others. In the tropical forests of Eastern Asia these species play the part which in Europe belongs to trees of Coniferæ and Cupuliferæ—the Scotch Pine, the Mountain Pine, the Spruce, and the Beech. The most remarkable of these gregarious species is the Sāl tree, *Shorea robusta*, which forms pure or nearly pure forests of vast extent at the foot of the Himalaya, from Assam to the Punjab, and in the hills of Eastern Central India extending south to near the Godavery river. In a climate and on soil which suits it, this tree reigns supreme. The most suitable soil is either sandstone, as in many parts of Central India, or alternating beds of shingle and sand, such as are found at the foot of the Himalaya, or loam resting on gravel and sand. The principal factors which enable this tree to maintain the upper hand over its associates in a climate and on soil suitable to its development may briefly be stated as follows:—The seed ripens at the right season of the year, at the commencement of the rains, after the forest-fires of the hot season have passed over the country; it is produced in great abundance regularly almost every year and germinates readily. The leaves of the seedling plants are very large, thus choking other trees and shrubs, which may have sprung up with them. When the ground is overrun by the jungle-fires of the following season, most seedlings of the previous year are strong enough to send up fresh shoots when the rains set in, although they may have been burnt down to the root. This gives the young Sāl plants a great advantage over other kinds which germinate at a less convenient season. Again, the Sāl stands much shade while young, it remains alive for

many years under dense cover of tall grass, of bushes, or other trees. It will be understood that these remarks relate to Sāl forests in their natural state. Where man interferes by cutting out the Sāl tree, because it is the most valuable timber, the forest of course assumes a different aspect.

Another species remarkable for its gregarious habits is the Eng tree of Burma, *Dipterocarpus tuberculatus*, Roxb., forming extensive forests, chiefly on laterite, at the foot of the hills in Pegu and Upper Burma. As in the case of Sāl, there is under the parent trees an abundance of younger trees of the same kind, of all ages down to seedlings. The same peculiarities which were noticed in the case of the Sāl tree also favour the growth of the Eng and give it, under suitable conditions of soil and climate, preponderance over its associates.

The following is a list of the principal species known to grow gregariously :—

1. *Dipterocarpus obtusifolius*, Teysm.—Eastern peninsula south of 20° N. lat. In Burma this takes the place of *D. tuberculatus* at higher levels.
2. *D. pilosus*, Roxb. (*D. Baudii*, Korth.).—Gregarious in Sumatra (*Korthals*), not gregarious in Burma.
3. *D. Duperreanus*, Pierre, and (4) *Jourdainii*, Pierre.—Cochinchina, gregarious (*Pierre*).
5. *D. tuberculatus*, Roxb.—Eminently gregarious on laterite in Burma.
6. *D. intricatus*, Dyer.—Gregarious on sandy soil in the plains of Cochinchina (*Pierre*).
7. *Anisoptera costata*, Korth., and (8) *marginata*, Korth. Gregarious on the hills of South-east Borneo (*Korthals*).
9. *Dryobalanops aromatica*, Gaertn. f.—Gregarious in Sumatra (*Korthals*).
10. *Hopea ferrea*, Pierre.—In one place in Lower Cochinchina gregarious, covering an entire hillside (*Pierre*).
11. *H. Recopei*, Pierre.—Gregarious, covering entire mountain-sides in the province Bienhon, Cochinchina (*Pierre*).
12. *Pentacme suavis*, A. DC.—In Lower Burma scattered, chiefly in the forests of *Dipterocarpus tuberculatus*; gregarious in Upper Burma (*J. W. Oliver*) and in Cochinchina (*Pierre*).
13. *Shorea robusta*, Gaertn. f.—Forms nearly pure forests of great extent at the foot of the Himalaya, extending in

places far into the plains, as well as on the hills of Central India from the Ganges to the Godavery river.

14. *Shorea obtusa*, Wall.—In Burma scattered, chiefly in forest of *Dipterocarpus tuberculatus*; in Cambodia forming pure forests (*Pierre*).
15. *S. Balangeran*.—Gregarious upon the banks of the Pattai river, Borneo (*Korthals*).
16. *S. hypochra*, Hance.—Gregarious in Cochinchina (*Pierre*).
17. *Vatica obscura*, Trimen.—Gregarious in the Eastern province of Ceylon (*Trimen*).

Those species which do not grow gregariously, though they may be common, occur as isolated individuals, often at considerable distances apart. The number of these is much greater than the number of gregarious trees. Yet many of them, such as Kanyin, *Dipterocarpus alatus*, flower and seed abundantly. A remarkable fact is, that of the large number of seeds of this species which were sent to me in alcohol from Burma very few were perfect, many were worm-eaten, while in others in the place of the embryo the fruit-cavity was filled up by a dry tissue resembling cork. I mention this fact, because two Indian species of *Anogeissus*, *A. latifolia* and *acuminata*, show the same peculiarity. Among large quantities of seed which I examined when studying Combretaceæ a few years ago, I only found a few with a perfect embryo. These trees produce seed abundantly every year, and yet they are not gregarious; but, like *Dipterocarpus alatus*, occur singly in mixed forests. The circumstances, which enable certain species in tropical or subtropical countries to form pure, or nearly pure forests will prove an interesting subject of biological research for those whose good fortune enables them to study these trees in their native forests.

It is a remarkable fact, that two natural orders of trees, Coniferæ and Dipterocarpaceæ, many species of which form nearly pure forests of large extent, form resinous substances on a large scale in their leaves and deposit them in the wood. A complicated system of resin-ducts is found in all parts of Dipterocarps as well as of Conifers. In the living tissue these substances are in a liquid oily condition; while in the old wood solid, in *Dryobalanops* crystalline, masses are deposited. It is beyond the scope of the present paper to enter into detail upon this important subject. In regard to *Dryobalanops*, I must refer the

reader to the account of the Sumatra Camphor by De Vriese in Kew Journ. Bot. iv. pp. 33, 68 (1852), and in regard to *Dipterocarpus*, *Shorea*, and other genera, to what I have said in Engler's Nat. Pflanzenfam. iii. 6. pp. 245, 257, 259, 266, &c., and in a paper of mine published in the 'Pharmaceutical Journal,' vol. liv. p. 497.

Most Dipterocarps are evergreen, the old leaves falling soon after the young foliage has developed. In some species, however, the duration of the leaves is a little under 12 months. Thus the Sāl tree is generally leafless during a week or two of the hot season, before the young leaves come out. This, however, varies according to locality and the peculiarities of the season.

Dipterocarps as a rule are large trees with tall branchless stems, which do not flower and seed until they have attained a large size and a great age. There are, however, exceptions. Many species of *Vatica* are shrubs or small trees, flowering at an early age. A well-known instance is *Vatica lanceæfolia*, Blume, of Assam and Cachar. This and similar species are readily gathered in flower and fruit. The species of *Pachynocarpus* and *Isoptera borneensis*, Scheff., grow into large trees; but according to information kindly communicated to me by Mr. Ridley, they flower and seed at an early age. The same I have noticed in Burma in the case of two large trees, *Pentacme suavis*, A. DC., and *Shorea obtusa*, Wall. On laterite or dry hills, where they are associated with *Dipterocarpus tuberculatus*, small (not always aged) specimens of these trees are often found in flower and seed.

As a rule Dipterocarps flower and seed annually, unusual seasons excepted. Mr. Ridley, who has devoted attention to this subject in the Malay Peninsula, informs me that *Dipterocarpus cornutus*, Dyer, *grandiflorus*, Blanco, *crinitus*, Dyer, *Vatica Ridleyana*, Brandis, and *Pachynocarpus Wallichii*, King, flower regularly each year, although any given tree may occasionally omit a year or more, even if adult. Mr. Ridley also states that every sixth year the weather becomes unusually dry, especially during the first half of the year, and that then many species of the order produce flowers and seed. The years 1888 and 1894, he states were such years, and in those years, among others, the following species were found in flower and seed:—*Hopea intermedia*, King, *Mengarawan*, Miq., *Shorea leprosula*, Miq.,

parvifolia, Dyer, *pauciflora*, King, *macroptera*, Dyer. These and others Mr. Ridley regards as sexennially flowering kinds; they flower with remarkable regularity, all blooming within one or two days of each other, so that, if one tree is found in flower or seed, all trees of the same kind in that district will be in the same condition.

External Morphological Characters.

The stipules are, as a rule, small and early deciduous. An exception is *Dipterocarpus*, where the large stipules form a good generic character. A small number of *Shoreas* have large stipules, which in some do not fall early. Most of them belong to section *Pinanga*, *S. grandiflora* and *macrantha*, sp. novæ, *purpuracea*, Miq., with semipersistent, *S. Pinanga*, Scheff., *S. Gysbertsiana*, Burck, with deciduous stipules. But in other species closely allied to them they are minute or caducous. Of section *Brachyptera*, *S. stenoptera*, Burck, and of *Anthoshorea*, *S. compressa*, Burck, have large stipules. One *Vatica*, one *Doona*, one *Stemonoporus* have large stipules, but as a rule the stipules in these genera are small and caducous.

The petiole is almost invariably thickened below the base of the blade, and this, as well as the lateral cortical leaf-traces, which often show in good herbarium specimens on a leaf-bearing internode, giving it an angular appearance, are useful characters to recognize specimens of this natural order. The leaves are coriaceous with few exceptions, and it is remarkable that most of these exceptions occur in the case of species which grow on the Philippine Islands. *Dipterocarpus vernicifluus*, Blanco, *affinis* and *speciosus*, nov. spp., as well as *Anisoptera thurifera*, Blume, and *Shorea furfuracea*, Miq., may be mentioned. However, even in the Philippine Islands, among the 26 species known, the majority have coriaceous leaves. The leaves are always penniveined, and the arrangement of the secondary and tertiary nerves affords useful specific, and in a few cases (*Shorea*, *Pachynocarpus*) also good generic characters. At the risk of being considered pedantic, I have adopted this designation, as it also holds good in leaves with several basal primary nerves. The tertiary nerves are either reticulate or parallel, and in the latter case more or less at right angles to the secondary nerves, in some cases to the midrib.

The underside of leaves is in some species clothed with minute and very thin round scales. As a rule the pubescence of leaves, petioles, stipules, branchlets, and inflorescence consists of stellate or fasciculate hairs, which are nearly always one-celled. An exceptional case of pluricellular hairs is on the inside of the calyx of *Vatica lanceæfolia*. The ramifications of the inflorescence, the calyx, and the outside of petals are, as a rule, hairy. *Dryobalanops* and *Doona* (most, but not all species), and some species of *Hopea*, form the most notable exceptions.

The inflorescence is, so far as my researches have gone, always racemose, never cymose. Racemes or spikes, very often unilateral, are arranged in axillary or terminal panicles, the branches of which are frequently distichous and regularly alternating. I have called these panicles racemose when the branches are not further ramified (Engler, Nat. Pflanzenfam. iii. 6, fig. 123 F, *Shorea Warburgii*, Gilg).

There are, however, numerous and most remarkable instances of flowers, which at first sight appear to be terminal, standing in a bifurcation of the inflorescence (Plate III. fig. 18, *Vatica perakensis*, King, subgen. *Synaptea*). A careful examination, however, shows that one of the apparently equivalent branches of the bifurcation is the main axis, and that the flower which is apparently terminal is in reality the lowest flower on either the main axis or the branch. In some cases, particularly in *Vatica lanceæfolia*, Blume (*Retinodendron*), there are 2 pseudo-terminal flowers, one the lowest flower of the main axis, the other of the branch (Plate III. fig. 4). Other species of *Vatica* with pseudo-terminal flowers are *V. pallida*, Dyer, and *sarawakensis*, Heim, both of subgenus *Retinodendron*. Most deceptive is *Vatica Mangachapoi*, Blanco (subgen. *Synaptea*). The specimens collected by Dr. Warburg of this species at first sight give the impression of a cymose inflorescence. A similar inflorescence I have found in other genera. A drawing of *Pachynocarpus umbonatus*, Hook. f. (Plate III. fig. 25), clearly shows that the apparently terminal flower belongs to the main axis on the left. *Anisoptera oblonga*, Dyer, and *Dipterocarpus intricatus*, Dyer, have a similar inflorescence. That of the last-named species is well represented on tab. 215 of Pierre's 'Flore Forestière de la Cochinchine.' In this species the bifurcation of the panicle with an apparently terminal flower seems to be the rule. In order finally to settle the question, whether the interpretation here given is correct,

the inflorescence of this species, as well as of others showing this remarkable arrangement, should be studied on fresh specimens on the spot or on sufficient alcohol material.

The flowers are generally on short, often very short, pedicels, and these pedicels as a rule are supported by 2 bracteoles. In some cases, particularly in species of *Vatica*, I have found a third bracteole between the two, or a trace of a third bracteole. Three bracteoles are frequent at the base of the ramifications of the inflorescence. Such a case is represented on Plate II. fig. 6 (*Hopea discolor*, Thw.). In this and similar cases the two lateral bractlets may be regarded as stipules, and there is no difficulty. As a rule, however, there is at the foot of the pedicel no trace of a median bracteole. Of the two, the one outside, which often is considerably larger, slightly overlaps the inner, and in these cases matters are not plain. To clear up this point also, examination of fresh material or of alcohol material will be necessary. The expression used by me " pedicel in the axil of 2 bracteoles" is not quite correct, for the pedicel stands in the axil of the inner (upper) bracteole. These bracteoles are generally small and early deciduous; they are, however, large in some species, covering the buds until the flowers open, viz. in *Shorea bracteolata*, Dyer, *Beccariana*, Burck, of section *Anthoshorea*, in *S. squamata*, Benth. et Hook., *furfuracea*, Miq., and *cristata*, sp. nov., of section *Pinanga*, and in *S. Curtisii* of section *Mutica*.

On the edge of the thick, obconical, sometimes concave, receptacle stand 5 sepals. The receptacle is concave in *Dipterocarpus*, *Anisoptera*, and some species of *Vatica* (subgen. *Synaptea*), and in these cases the fruit is enclosed entirely or at the base only by the enlarged hollow receptacle or calyx-tube as it may also be called. When the sepals stand on the edge of a flat receptacle, they are valvate if narrow (*Parashorea*, *Vaticeæ*), imbricate if broad (*Shoreæ*, *Vaterieæ*). The petals are twisted in bud, overlapping either with the right-hand or with the left-hand edge. When in the case of an imbricate calyx the third sepal overlaps with the right-hand edge, the reverse is the case in the petals, and *vice versâ*.

By far the majority of species have 15 stamens, the 5 innermost standing in front of 5 outer stamens, their filaments being often connate. These 10 stamens, which stand in pairs, are episepalous, while the other 5 outer stamens are epipetalous. There are thus 5 regularly alternating whorls, sepals, petals, and 3 circles of

stamens. In a few species of *Hopea, Vatica,* and *Balanocarpus* the number of stamens is reduced to 10, in *Monoporandra* to 5, which are episepalous. On the other hand, there is a larger number of stamens in species of *Shorea* (section *Eushorea* and subsection *Hopeoides* of *Anthoshorea*), in *Isoptera, Dryobalanops, Dipterocarpus,* and *Vateria.* The number of the stamens, the conformation of the filaments, the structure of the anthers, and the prolongation of the connective afford most useful characters for the systematic arrangement of genera and species, as may be seen in the detailed description.

The ovary is 3-celled, the placenta being in the inner angle of the cells. To the placenta near the top are attached 6 anatropous ovules, 2 in each cell, the micropyle looking upward and outward. In many species there is above the ovary-cells a fleshy stylopodium, varying in shape and size. It is wanting in *Vaticeæ, Vaterieæ, Dryobalanops, Doona,* as well as in several species of *Hopea* and *Shorea.* Its existence or absence, as well as its conformation, furnishes excellent systematic characters. In many species with a stylopodium the style is short, in *Dipterocarpus* long, and in *Anisoptera* there are 3–6 short styles on the top of a large fleshy stylopodium. As a rule, even where there is no stylopodium, the ovary is gradually narrowed into the style. There are, however, species in which the ovary is blunt and not gradually narrowed into the style, and in these cases the style is often articulate with the ovary. This is the case in most species of *Stemonoporus,* and in *Shorea contorta,* Vidal, of section *Anthoshorea.* The style is always glabrous, the stylopodium often hairy, even when the ovary is glabrous (Plate II. fig. 21, *Shorea inappendiculata,* Burck).

The fruit is supported by the persistent, and in nearly all species enlarged or thickened calyx. In *Dryobalanops, Parashorea,* and *Vatica,* section *Isauxis,* all segments develop into large wings, much longer than fruit; in *Dipterocarpus, Anisoptera, Hopea, Cotylelobium,* and *Vatica* (subgenus *Synaptea*) only two, and where the calyx is imbricate the two outer ones. In *Shorea, Doona,* and *Pentacme* the two outer and the third (half outer) segments lengthen out into long wings. In *Vaterieæ, Vatica* (subgenus *Retinodendron*), *Pachynocarpus, Balanocarpus,* and *Isoptera* the calyx-segments are enlarged, thickened, sometimes connate with the fruit, but they are equal, and shorter or not much longer than the fruit.

Of the 6 ovules, as a rule one only develops into a perfect seed. At present three exceptions only are known. Two seeds in one fruit have been found in *Dipterocarpus condorensis*, Pierre, *alatus*, Roxb., and *Dryobalanops aromatica*, Gaertn. f. The seed fills the entire fruit-cavity. As the one favoured seed grows, the dissepiments, which are often very thin, are pushed aside or torn, but the placenta remains attached to the base of the fruit-cavity, it becomes hard and woody, and with the remains of the dissepiments is, as a rule, enveloped by the testa and cotyledons. The 5 abortive ovules increase a little, they become hard and shining, and in most species may be seen attached to the placenta at the apex. Sometimes, as in species of *Dipterocarpus*, the abortive ovules are on the outside of the seed in its upper part, attached in a circle to the testa.

In its structure the seed shows great variety, and it may at once be stated that in this order the structure of the seed does not afford any certain generic characters. However, most species have one point in common—the cotyledons have long petioles when the seed germinates, and in many cases these petioles are well developed in the seed before germination.

As may be concluded from the position of the anatropous ovule, the radicle is superior, that is its tip is directed towards the apex of the fruit. The radicle, or, more correctly speaking, the hypocotyl, varies in length and is often as long as the embryo. In this case the point where the cotyledons are attached to it is situated near the base of the fruit-cavity. The cotyledons are often unequal in size, one being larger than the other; in the majority of cases they are bifid to the base, that is to the point where they are attached to the hypocotyl. In many species they are divided into numerous lobes. Very often they are auriculate at base, and when the radicle is short it is included between the auricles.

A considerable number of species have albumen in the mature seed. In these cases the embryo is small, the cotyledons are flat and thin, more or less folded, and sometimes lobed. Albuminous seeds are known from several species of *Dipterocarpus*, *Hopea*, *Vatica*, and *Stemonoporus*, and it seems probable that they will be found in all large genera. Species with albuminous and exalbuminous seeds are often closely allied and very similar.

Regarding the structure of the exalbuminous seeds, the reader must be referred to the detailed description under each species

of which seeds were available for examination. The variety is so great that any attempt at classification is exceedingly difficult. Species otherwise closely allied show great differences in the structure of the embryo. Speaking very broadly, the following types may be distinguished, but they in no way exhaust the great variety of structure that is actually found :—

I. The cotyledons are thick, fleshy, plane-convex, entire or bifid, the hypocotyl being imbedded between them on the face of contact. *Vatica* (section *Retinodendron*), *Isoptera*, *Vateria*. The hypocotyl varies in length. It is short, enclosed between the auricles of the cotyledons (*Vatica Schumanniana*, Gilg). It is as long as the embryo, and consequently the attachment of the cotyledons is near the base of the fruit-cavity (*Vatica Roxburghiana*). It has about half the length of the embryo, the cotyledons being attached to it about the middle of the seed (*Vatica obscura*, Trimen, *V. lanceæfolia*, Blume, *V. moluccana*, Burck).

II. The cotyledons are flat, but many times folded and twisted, the whole often appearing as a homogeneous mass, in which the radicle alone can be distinguished. The testa enters into the folds of the cotyledons. Radicle short. *Dipterocarpus*, *Doona*.

III. The cotyledons are fleshy, but they are bent or folded along their midrib or median line. The outer cotyledon is concave, more or less embracing the inner (Engler, Natürl. Pflanzenfamilien, iii. 6. fig. 118 B, 120 G, H). The hypocotyl is situated between the auricles or the lobes of the outer cotyledon, which may be termed the radicular. The lignified placenta is more or less enclosed by the inner, which may hence be called the placentar cotyledon. The radicle lying on the outside, the placenta being in the main axis of the fruit, the radicular may also be termed the anterior, and the placentar may be called the posterior cotyledon. The embryo of this type varies according to the length of the hypocotyl: it is short in *Dryobalanops*, *Parashorea*, *Pentacme*, *Vatica astrotricha* (*Synaptea*), and several species of *Shorea*; it is long in *Anisoptera*, *Hopea*, species of *Shorea* of sections *Eushorea*, *Anthoshorea*, and *Pinanga*.

Stemonoporus and *Cotylelobium* have their cotyledons divided

into numerous lobes, there is an outer, slightly concave cotyledon, and they may be classed under this type.

IV. The cotyledons are fleshy, bifid to base, and the four lobes are prismatic, 3-sided, the two inner faces flat, the third outer face rounded; the hypocotyl, which generally is nearly as long as the embryo, is imbedded in a groove on the inner edge of the 4 cotyledonar lobes. This type is found in 4 species of *Balanocarpus* and in 6 species of *Shorea*, belonging to the sections *Brachyptera, Pinanga,* and *Mutica,* also in *Hopea globosa,* nov. sp. (Plate II. fig. 25, *Balanocarpus coriaceus*).

Two remarkable facts connected with the structure of the seed must here briefly be noticed. In *Balanocarpus* the testa, which in this genus is thinly membranous, loosely enveloping the seed, seems to be adnate to the inner surface of the pericarp at the base of the fruit-cavity, at the foot of the persistent placenta. In *Stemonoporus* there is at the base of the fruit-cavity a remarkable fleshy or fibrous cup-shaped excrescence, Heim's "cupule chalazique." Both facts must remain obscure until light can be thrown upon them by the study of fresh or alcohol material in different stages.

The non-nitrogenous substances stored in the seed are starch and fat. So far as known, starch prevails in *Dipterocarpus, Doona,* and *Vatica*; fat in *Pentacme* and *Isoptera.* In other genera it varies. *Dryobalanops aromatica,* starch; *D. oblongifolia,* fat. *Hopea odorata,* starch; *H. ferrea,* fat. *Shorea robusta* and *obtusa,* starch; *S. Gysbertsiana, Pinanga, stenoptera, aptera, hypochra,* fat.

Anatomical Characters.

The peculiar anatomical characters of *Dipterocarpaceæ* have long ago attracted the attention of Botanists, and there is now a considerable literature on the subject, the more important publications being the following:—Konrad Müller, "Anatom. Verh. der Dipterocarpaceen," in Engler's Bot. Jahrb. ii. p. 446 (1882). —Ph. van Tieghem, "Canaux sécréteurs des Plantes," Ann. Sc. Nat., Septième série, Bot. i. (1885), Diptérocarpées, p. 59.— Solereder, Systemat. Wert der Holzstructur (1885), Dipterocarpeen, p. 81.—Burck, "Sur les Diptérocarpées des Indes

Néerlandaises" (1887), Ann. Jard. Bot. Buitenzorg, vi. p. 145. —PIERRE, Flore Forestière de la Cochinchine, tabb. 212-259 (1889-92).—HEIM, Recherches sur les Diptérocarpacées (1892).

It is not my object in this place to do more than to draw attention to a few facts which are useful for the systematic treatment of this order. I mean the course of the leaf-traces through the stem to the petiole, the distribution of resin-ducts in a leaf-bearing internode, and the structure of the petiole. I shall say nothing on the present occasion regarding the internal structure of the leaf, the seed, wood, bark, root, and other parts of the tree. The points in question may best be understood by the examination of leaf-bearing internodes, and for purposes of comparison petioles should always be examined at the base of the blade.

In common with Lecythidaceæ, Ochnaceæ, and a few other orders, Dipterocarps have the peculiarity that the lateral leaf-traces and sometimes the apical leaf-trace separate from the central cylinder a greater or less distance below the node, running through the bark until they enter the petiole. In those species where the stipules are broad, stipular traces also are found in the bark. As a rule there is one apical leaf-trace and two lateral leaf-traces, the stipular traces, if any, separating either from the lateral leaf-traces or from the central cylinder. These leaf-traces are vascular bundles, either circular, closed all round, or open and half-moonshaped, consisting of phloëm, xylem, and pith, with one, sometimes several resin-ducts in the pith.

When these leaf-traces separate from the central cylinder, the opening of the half-moon is inwards towards the cylinder (Plate I. figs. 11, 12, *Dipterocarpus*). Circular leaf-traces are represented on Plate I. figs. 2, 3 (*Dryobalanops*). When the lateral leaf-traces bend, preparing to enter the petiole, xylem and phloëm are directed towards the insertion of the petiole (Plate I. fig. 9, *Hopea cernua,* fig. 10, *Shorea obtusa*).

The apical leaf-trace generally leaves the central cylinder at the node in order to enter the petiole, while, as already mentioned, the lateral leaf-traces generally leave it at a lower level. *Stemonoporus*, and probably also the other species of *Vaterieæ*, however, are an exception. Here the apical leaf-trace branches off from the central cylinder at a distance below the node, and after separating into 3 or 5 separate vascular bundles, runs through the bark for some distance before entering the petiole.

The lateral traces leave the central cylinder at a higher level, and do not enter into the leaves, but into the stipules. Here, therefore, the apical precedes the lateral traces, while as a rule the lateral precede the apical trace.

Another peculiarity of Dipterocarps is, that there are resin-ducts in the pith of the internode and of the leaf-traces. These resin-ducts, being exceedingly prominent on transverse sections, first attracted the attention of anatomical botanists. In *Dryobalanops* there is one main duct in the centre of the pith, sending out branches at different levels, so that in a transverse section several ducts as a rule are seen. This genus has another peculiarity, that the lateral leaf-traces often run through the bark for an entire internode. On good herbarium specimens these cortical leaf-traces may be readily distinguished as longitudinal raised lines (Plate I. fig. 17), and a good lens shows the distribution of the resin-ducts on a transverse section.

In the other genera the resin-ducts are on the circumference of the pith, and they are more numerous. These ducts send branches into the leaf-traces, both into the apical and lateral. For this purpose the duct has to make its way through the belts of xylem and phloëm which enclose the pith. The first change noticed is, that the medullary rays of the xylem arrange themselves like the rays of a fan (Plate I. figs. 4, 5, *Dryobalanops*). The further progress through the wood may be seen in fig. 8 (*Hopea cernua*), and in the case of stipular traces in figs. 11 and 12, *Dipterocarpus alatus* and *pilosus*. It is a remarkable fact, which I have observed in all species of this order examined by me, that of two corresponding lateral leaf-traces one is always in advance of the other, both are never in exactly the same stage. The figures on the Plates which accompany this are not sufficiently magnified to show this remarkable feature in all instances. Fig. 1 of Plate I., however, clearly represents the left-hand lateral trace in advance of the other. In addition to the ducts which go into the leaf-traces and stipular traces, a number also go into the axillary bud. After the petiole has separated from the central cylinder, or even before the petiole has been fully formed, the central cylinder narrows into a neck with a number of resin-ducts (Plate I. fig. 10, *Shorea obtusa*). Vascular bundles branch off from this neck and go straight through the bark into the axillary bud. The number of resin-ducts in those genera which have them in the circumference of the pith varies

exceedingly. The number is largest in *Dipterocarpus*, up to 100 having been observed, sometimes arranged in several concentric circles. This genus is, moreover, distinguished by the large number of stipular traces which enter the bark a little above the lateral leaf-traces, each with a resin-duct in the pith. In most species there are also large mucilage-cavities in pith and cortex.

What has been stated will make it clear that the genus *Dipterocarpus*, *Dryobalanops*, and *Stemonoporus* can always be readily recognized by the arrangement of leaf-traces and stipular traces, and by the number and arrangement of the resin-ducts. *Vateria* and *Monoporandra* probably agree with *Stemonoporus*, but on this question my researches have not yet been concluded. All other genera, so far as known, have the normal arrangement, that is the lateral leaf-traces separate from the central cylinder at varying levels, while the apical leaf-trace leaves it at the node, all three entering the petiole, stipular traces, if any, branching off from the central cylinder or from the lateral traces. In the circumference of the pith there is a circle of resin-ducts varying in number from 3 to 30. *Doona* is distinguished by mucilage-cavities in pith and cortex.

The vascular bundles in the petiole of Dipterocarps originate in the leaf-traces. As a rule, therefore, three vascular bundles, each with a resin-duct in the pith, enter the petiole. In most cases these original vascular bundles, and the resin-ducts which accompany them, ramify, and the result is a very intricate mass of xylem and phloëm with a considerable number of resin-ducts. Those cases where the petiole in its entire length has only three resin-ducts are rare; *Vatica obscura*, Trimen, is one of the few species known to me. *Dryobalanops* has 5 ducts in the petiole from base to insertion of the blade. Plate I. fig. 5 shows the petiole still attached to a branch of *D. lanceolata*, Burck, and fig. 6 represents a section a little higher up. Here the duct of the apical leaf-trace (*cf.* fig. 4) occupies the underside of the petiole and has not divided. The two lateral ducts, however, which in fig. 4 are in the lateral cortical leaf-traces, have each bifurcated, the branches on the underside being outside the mass of vascular bundles, a feature peculiar to all species of the genus. Here, therefore, the petiole at the base has 5 resin-ducts, and these 5 ducts continue throughout its length to the blade.

In most species the internal structure of the petiole changes considerably in its progress from the base to the insertion of the

blade. Plate I. figs. 13–15 represent sections through the petiole of *Hopea cernua*, T. et B., at different levels. At the base (fig. 13) are, apart from a central mass without resin-ducts, three distinct vascular bundles—xylem at the ends, pith in the centre, and phloëm all round. Each of these has a resin-duct, no bifurcation therefore has yet taken place. Near the top of the petiole, however (fig. 14), the lateral ducts have subdivided. At the base of the midrib (fig. 15) the 3 vascular bundles have united and now form a semicircle, with a bend below, consisting of xylem, phloëm, with bast-fibres outside. The bast continues and forms a closed ring, at the top on the inside, with bands of xylem and phloëm. It will be noticed that there is a central body of vascular bundles, which has gradually changed its shape, forming at the base of the midrib two horizontal bands—the lower xylem with phloëm below; the upper a double band, xylem on both sides and phloëm in the middle. The midrib in this and all other cases gives off branches into the secondary nerves, each accompanied by a resin-duct. The consequence is, that the number of resin-ducts diminishes gradually from the base to the end of the midrib. In order to compare the structure of the petiole in different genera and species, it is necessary to examine them all at the same point, and the most useful point for this purpose is the top of the petiole just under the blade, or the base of the midrib. At this point we invariably find in the underside of the petiole an outer semicircle of vascular bundles, generally more or less halfmoon-shaped and more or less confluent, the phloëm with a belt of bast-fibres outside, then the xylem, and at last the pith. Plate I. fig. 16 shows a section of the petiole of *Hopea odorata*, Roxb., below the blade, with a semicircle of 9, and fig. 18 a section of the midrib at base, of *Vateria acuminata*, Hayne, with 11 vascular bundles and the same number of resin-ducts in the outer semicircle. In both cases the vascular bundles are confluent and the outer ring is entirely closed. In *V. acuminata* the outer band of (white) bast-fibres is clearly shown, they are less distinct in *H. odorata*. The central mass in both cases consists of two halfmoon-shaped vascular bundles, in *Hopea* without, in *Vateria* with 6 resin-ducts.

These remarks will suffice to give a preliminary idea of the great variety in the internal structure of leaf-bearing internode and petiole. Under each genus I have endeavoured briefly to state what at present is known on this subject, and to these

remarks I must refer the reader. Burck and Heim have attempted to establish complete diagnostic generic characters taken from the internal structure. Some of the conclusions arrived at by these authors do not commend themselves to me, and, where it appeared necessary, I have explained this in its proper place. In my opinion the internal structure of a much larger number of species must be studied before a satisfactory diagnostic table of the genera, based upon anatomical characters, can be established.

It must not be forgotten that the application of anatomical characters to systematic botany is as yet in its infancy. We have still to learn which characters are essential in a particular genus or species. In *Dryobalanops*, for instance, the great length of the cortical leaf-traces seems to be an essential character; in *Anisoptera* their length seems to vary between one-half and an entire internode; *Vatica*, with few exceptions, has hardly any cortical leaf-traces, the lateral traces separating from the central cylinder close under the node. In *Doona* and *Hopea* they are short; but in *Shorea* there is great variety, the cortical leaf-traces being very short in some species, while in others they run through one internode and a half. I have already drawn attention to the raised lines visible on the outside of an internode, which in *Dryobalanops* readily indicate the length of the cortical leaf-traces. In other genera, particularly in *Shorea*, I have often found these raised longitudinal lines deceptive. It may be that in these species the central cylinder bulges out before the lateral leaf-traces have entered the bark, thereby producing raised lines even where the traces have not yet separated from the central cylinder.

As regards the number of resin-ducts in the pith at the base of the internode, *Dryobalanops*, as already mentioned, occupies an exceptional position; and the same holds good for a number of *Hopeas* of the section *Dryobalanoides*. In *Shorea*, as justly observed by Burck and Heim, there is great variation (in *S. robusta* from 3 to 20). In other genera the number seems to fluctuate within narrow limits. So far as known at present, in *Balanocarpus* and *Vatica* the number varies from 10 to 20, in *Anisoptera* from 18 to 24.

In several genera the ducts are unequal in width, the larger ducts having 10 to 15 times the diameter of average cells of the pith. In *Vatica* they are generally small, only 1–3 times the

diameter of average pith-cells, while in some species of *Shorea* (section *Anthoshorea*) they are very small, about the width of pith-cells, and consequently not easy to recognize.

A character not yet mentioned, upon which Heim lays great stress, are the sclerotic cells in the cortex. They either have their walls uniformly thickened all round (*Anisoptera*, *Vatica*, *Stemonoporus*, *Vateria*), or the wall is thickened on the inner side only. Those last named may be designated as horse-shoe or C-shaped cells, the thin wall being outside, towards the epidermis (*Doona*, *Hopea*, *Shorea*). Both kinds of sclerotic cells are found in the cortex of *Dryobalanops* and some species of *Dipterocarpus*.

Anatomical characters are not in themselves more valuable than external morphological characters. The progress of scientific research has not been furthered by the attempt to give undue weight to characters drawn from the internal structure of plants. Van Tieghem lays stress upon the affinity of *Mastixia* to Dipterocarps, because it has a circle of resin-ducts in the medullary sheath; and for similar reasons Van Tieghem and Lecomte have suggested that *Leitneria* should be placed in this order. This means that certain isolated anatomical characters are necessarily of paramount importance, and ought therefore to override the whole of the external morphological characters upon which the present classification of phænogamous plants has been based.

Obviously this is wrong. All characters must be weighed most carefully, whether external or anatomical, with the aim of determining which characters in a certain order, genus, or species should be regarded as essential; and the art of the systematic botanist consists in the judicious selection of those characters which are most useful in indicating the affinity of orders, genera, and species. As a matter of course, the affinity of different plants in reality consists in their entire organization, and not in the characters which the systematic botanist selects for purposes of classification and description. For these purposes a restricted number of characters must necessarily be selected. This selection, however, must be based upon the study of the entire organization of the plant, its mode of growth, its relation to light and shade, and other matters, which may conveniently be designated as Biological features. It must, further, be based upon the study of its internal structure as well as upon those external characters which in phænogamous plants have chiefly

been the guide of systematic botanists, until what is now called the anatomical method has been brought to his aid. In no case must the work of classification be based upon isolated characters, whether biological, anatomical, or external.

Our knowledge of the organization of any order, genus, or species is as yet fragmentary in phænogamous plants; it is necessary to advance step by step; and hence it seemed right, in dealing with the anatomical characters of Dipterocarps on the present occasion, to limit my remarks to the leaf-traces and resin-ducts in a leaf-bearing internode, and to the internal structure of the petiole.

It will be readily admitted that those characters which are apt to be influenced by the surrounding medium, by soil and climate, are of comparatively little value for systematic arrangement; and this is one reason why great caution must as a rule be used in employing characters taken from the internal structure of *leaves* for systematic purposes. However, as far as Dipterocarps are concerned, the external conditions under which they live in their native country are exceedingly uniform, comparatively speaking. They inhabit a limited range of countries with a moist tropical climate and alternating dry and wet seasons, where the general climatic features are very much the same.

Anatomical characters must be used with caution; but that holds good equally in the case of external morphological characters. Their study, however, in the order here under consideration has so far advanced, that without anatomical examination of internode and petiole no new genus of Dipterocarps can usefully be described.

The treatment of genera and species in the following pages is somewhat unequal. My aim throughout has been to draw attention to points which had not hitherto, in my opinion, received sufficient attention. As regards species, my intention was not to give complete lists of synonyms or of literary references, but reference has always been given to one standard work where the needful details can readily be found. With few exceptions, I have maintained the species as established by other authors. I am disposed to think that a critical examination of more abundant material will result in the disappearance of a number of species. However, my opinion is, that less confusion will arise by maintaining these doubtful species for the present than by uniting them on insufficient grounds.

In conclusion, I desire to thank all those who have furnished me with the materials for these researches. From India I have received valuable material in alcohol, through Mr. Hill, Officiating Inspector General of Forests; from Mr. J. S. Gamble, Conservator of Forests and Director of the Imperial Forest School, Dehra Dun; from Dr. King, Superintendent of the Botanic Garden, Calcutta; and from Mr. Duthie, Superintendent of the Botanic Garden, Saharunpore. From Burma, Colonel Seaton, formerly Conservator of Forests in the Tenasserim Division, and Mr. Oliver, Conservator of Forests, Upper Burma, have sent me most valuable specimens. Most important contributions from Ceylon, seed and seedlings in alcohol, with dried specimens, I owe to the kindness of Mr. A. F. Broun, Conservator of Forests in that island. Mr. Broun has also placed at my disposal his sketches representing germinating seeds in different stages, of *Dipterocarpus*, *Doona*, *Vatica*, and *Vateria*. Dr. Warburg, Berlin, has generously entrusted his Philippine collections to me for examination; and Mr. Holmes, Curator of the Museum, Pharmaceutical Society, Great Britain, has furnished me with valuable material for examination, and has permitted me to compare the specimens of the herbarium in his charge with those preserved at Kew. To Mr. George Brebner I am indebted for the anatomical drawings, from sections prepared by me, on Plate I. Mr. C. B. Clarke, President Linnean Society, has most kindly assisted me in the matter of literary references. Lastly, I have to thank the authorities at the Royal Herbarium and Botanical Museum, Kew, and at the British Museum, who, with unvarying kindness, have permitted me to examine the rich collections in their charge. It gives me great pleasure to thank all these kind friends for the valuable help they have given me on this occasion.

I. DIPTEROCARPEÆ.

Dipterocarpus, *Gaertn. f.*

Large trees, with tall regularly shaped trunks; some species gregarious, others scattered in mixed forests. Stipules large, amplexicaul, leaving conspicuous obliquely ascending scars. Secondary nerves mostly straight, joined by parallel and reticulate tertiary nerves. In bud the two halves of the leaf are folded upon each other, and the sections contained between two

secondary nerves are also folded in half. The folds between two secondary nerves in most species are clearly seen in the mature leaf, and in some cases the tertiary nerves show an angle along the line of this fold. Flowers large, in few-flowered racemes, which are sometimes branched. Receptacle concave, continued into a campanulate, tubular, or obconical tube, the segments of which are valvate or slightly imbricate in bud, unequal in size, two segments being longer. Petals at the base often cohering, but not connate. Stamens ∞, the anthers sometimes twisted. Connective prolonged into a long pointed acumen; valves generally equal, in some species (*D. Hasseltii*, Blume, *D. crinitus*, Dyer, *D. insularis*, Pierre) unequal. Ovary generally hairy, continued into a conical fleshy stylopodium, terminating in a filiform style and a minute stigma. Tube of fruiting-calyx not adnate to fruit, globose or ovoid, smooth or with five ribs or wings, alternating with segments, and formed by the decurrent margins of the segments, two of which develop into large membranous or coriaceous wings. Pericarp thin at the base, thick and fibrous in its upper portion.

The mature seed often albuminous, and in this case the cotyledons thin, folded, and often lobed. When in the mature seed all albumen has been consumed, the cotyledons are intricately folded. Hypocotyl (radicle) generally short. The cotyledons of the germinating seed remain enclosed in pericarp and tube of fruiting-calyx, being attached to the hypocotyl by petioles which sometimes are 5–6 inches long.

The pith of a leaf-bearing internode, near the circumference, has a large number, up to 100, resin-ducts, which sometimes are arranged in two concentric circles. There are 3 leaf-traces, 2 lateral and 1 apical; the lateral leaf-traces enter the bark at varying levels, generally in the upper half of the internode. Besides these, a number (7–12) of stipular traces are in the bark below the node, and afterwards enter into the amplexicaul stipules (Plate I. figs. 11, 12). Burck and Heim state that 5–9 (not 3) cortical leaf-traces enter the petiole. The petiole below the insertion of the blade shows on the underside a semicircle of 5–12 halfmoon-shaped vascular bundles, either continuous or distinct, each with a resin-duct. This semicircle is more or less closed on the upperside by a bar of xylem with phloëm outside (in *D. pilosus*, Roxb., there is a continuous ring of xylem and phloëm with 11 resin-ducts). A central body of vascular bundles, varying

in shape, with 1–8 resin-ducts. In most species large mucilage-cavities in pith and cortex.

A large well-marked genus, of which at present 64 species are known, which are found from Ceylon and the Western Peninsula of India to the Philippine Islands—viz., 2 in the Western Peninsula, 5 in Ceylon, 27 in the Eastern Peninsula, 22 in Borneo and other islands of the Indian Archipelago, 8 in the Philippine Islands. Five species have a comparatively wide distribution, viz., *Dipterocarpus pilosus*, from Assam to Sumatra and Bangka; *D. oblongifolius*, Blume, and *crinitus*, Dyer, from the Malay Peninsula to Borneo; *D. Hasseltii*, Bl., and *grandiflorus*, Blanco, from the Malay Peninsula to the Philippine Islands. For the present Mr. Dyer's arrangement (Journ. of Botany, 1874, p. 102) may be adopted.

Sect. I. SPHÆRALES, *Dyer*.

Tube of fruiting-calyx smooth.

A. *Ceylon and Western Peninsula.*

1. DIPTEROCARPUS INDICUS, *Bedd. in Madras Forest Report* (1864–65), 17, cum tab., *et Fl. Sylv.* (1871) t. 94.—D. turbinatus, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 295, partim; *Talbot, Trees Bombay*, p. 17; *non Gaertn.*

Evergreen forest on the ghats of North Canara (*Talbot*); ghats of South Canara (*Bedd.*). The origin of specimens at Kew marked Concan (*Stocks*) is doubtful. Travancore, Colatoorpolay (*Lawson*, n. 12).

Closely allied to *D. turbinatus*, Gaertn. f., the distinguishing characters, so far as known at present, being the long petioles, ½ to ¼ length of blade, and the smaller number of secondary nerves, 10–15 only.

In regard to the pubescence of young shoots and inflorescence, it varies in the same way as *D. turbinatus*. Mr. Lawson's specimens from Travancore are perfectly glabrous. Until better specimens in fruit are available, it seems preferable to keep this species distinct. Eventually it may prove to be a local variety of *D. turbinatus*.

2. D. HISPIDUS, *Th. Enum. Pl. Zeyl.* (1859) 33; *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 102, t. 143. fig. 14; *Trimen, Fl. Ceylon*, i. 114.

Ceylon, moist low country.

B. *Eastern Peninsula.*

3. DIPTEROCARPUS TURBINATUS, *Gaertn. f. Fruct.* iii. (1805), 51, t. 188; *Dyer in Hook. f. Fl. Brit. Ind.* i. 295, partim; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 92.—D. lævis, *Ham. in Mem. Werner. Soc.* vi. (1832) 299; *Kurz, Forest Fl. Brit. Burma*, i. 114; *Gamble, Manual of Indian Timbers*, 32.

Cachar; Chittagong hills; Burma; Andamans; Malacca. "*Gurjun-tree*," Chittagong. "*Kanyin-ni*," Burma. Not gregarious, but scattered in mixed forests, generally taller than the trees associated with it. Yields large quantities of wood-oil.

Roxburgh describes the leaves as smooth on both sides, but I agree with Dyer and King that petioles, branchlets, and the underside of leaves are often pubescent. There is also a certain variation in the nervation of the larger wings of the fruiting-calyx. The original fruits upon which Gaertner based his species have penniveined wings, the two lateral nerves not extending much beyond half their length. Dyer (Journ. Bot. 1874, tab. 143. fig. 13) represents three basal nerves extending through the entire length of the wings, with two shorter lateral nerves. One of Hamilton's specimens, preserved in the British Museum, is remarkable for its strong pubescence on petioles, underside of leaves, and wings of fruiting-calyx, as well as for the three longitudinal nerves of the calyx-wings. Hamilton calls the pubescent form *D. turbinatus*, and the glabrous form *D. lævis.*

4. D. VESTITUS, *Wall. List* (1828), n. 954; *Dyer in Hook. f. Fl. Brit. Ind.* i. 295.

Tavoy.

5. D. OBTUSIFOLIUS, *Miq. Ann. Mus. Lugd.-Bat.* i. (1863–64) 214; *Dyer in Hook. f. Fl. Brit. Ind.* i. 295; *Kurz, For. Fl. Brit. Burma*, i. 115; *Teysm. MS. fide Miq.*

Through the entire Eastern Peninsula, but not at present known north of 20° N. lat. In places gregarious on laterite and sandy soils in Pegu and Martaban, ascending to 3000 feet, taking the place of *D. tuberculatus* at higher elevations. In Cochinchina and Cambodia very common and gregarious.

6. D. PILOSUS, *Roxb. Hort. Beng.* (1814) 93, *et Fl. Ind.* ii. 615; *Dyer in Hook. f. Fl. Brit. Ind.* i. 296; *Kurz, For. Fl. Brit. Burma*, i. 115.—D. Baudii, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 59, t. 5.

Damp forests in the upper part of the Assam valley; Chittagong hills; Aracan; Lower Pegu; hills between the rivers Sitang and Salween; possibly on the Andamans (*King, l. c.* 99); Sumatra, where, according to Korthals, it grows gregariously; Bangka.

Burck, *l. c.* pp. 198, 199, keeps *Dipterocarpus Baudii* and *D. pilosus* separate. But Korthals's specimens and his excellent figure agree perfectly with the Indian specimens, so far as leaves and fruit are concerned. Regarding the flowers, which of Indian specimens I have not seen, we have the description of Kurz, drawn up presumably from Burma specimens, which agrees with Korthals's figure, particularly in the "calyx tawny tomentose from stellate hairs." Regarding the fruit of *D. pilosus*, Vidal, see under *D. affinis*.

The specimens of *Dipterocarpus* collected by Sir Joseph Hooker in the hills north of Chittagong (*cf.* Himalayan Journals, ii. pp. 348, 353) mostly belong to *D. turbinatus*; but there are also others with hairy branchlets, petioles, and leaves, which have justly been referred to *D. pilosus*. These Chittagong specimens of *D. pilosus* are remarkable for their narrow, almost lanceolate leaves.

7. Dipterocarpus crinitus, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 296; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 90.

Probably over the whole southern portion of the Malay peninsula. Malacca; Perak; Pahang (*Ridley*); Borneo (*Beccari*, nn. 779, 1883).

8. D. Scortechinii, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 91.

Perak.

9. D. Skinneri, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 91.

Penang.

10. D. Kerrii, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 93.

Malacca; Pangkore.

11. D. Duperreanus, *Lanessan, Pl. Utiles Col. Fr.* (1886) 297; *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), t. 219.

Cochinchina. On the hills, up to 230 metr. alt., in the province Bienhoa, gregarious, forming pure forests of large extent.

12. DIPTEROCARPUS JOURDAINII, *Lanessan, Pl. Utiles Col. Fr.* (1886) 298; *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), t. 220.
Cochinchina. Gregarious in the plains and on the hills.

13. D. PUNCTULATUS, *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), t. 221.
Cochinchina.

14. D. (?) CONDORENSIS, *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), t. 214, C.
Pulo Condor Island, Cochinchina.
An anomalous species, of which the fruit only is known. One segment of fruiting-calyx a little longer than the others and longer than fruit. Sometimes two seeds in fruit. Seed exalbuminous; cotyledons convolute and folded.

C. *Java, Sumatra, Borneo, and other Islands of Malay Archipelago.*

15. D. TAMPURAU, *Korth. Verh. Nat. Gesch. Bot.* (1839–42), 63.
Borneo (*Korthals*), nom. indig. "Tampoeraoe."
Burck (in Ann. Jard. Buitenz. vi. (1887) 198) identifies with this Beccari nn. 779, 1883, which are quoted by Dyer (in [London] Journ. Bot. xii. (1874) 103) under *D. crinitus,* and which have leaves 3–5 in. long, $1\frac{1}{2}$–2 in. wide, and wings of fruiting-calyx 3 in. long. Korthals describes the leaves of *D. Tampurau* as 20 in. long, 9 in. wide, and the wings of the fruiting-calyx as 13 in. long, 3 in. broad. As King (in Journ. Asiat. Soc. Bengal, lxii. pars 2 (1893), 91) correctly says, *D. Tampurau* seems to be quite different from *D. crinitus,* Dyer, with which Burck identifies it. The dimensions, as given by Korthals in inches, are copied in A. DC. Prodr. xvi. (pars 2) 609: this with reference to Burck's remark that the entry in DC. Prodr. is erroneously given in inches instead of in centimetres. The point is, whether Korthals's specimens, which I have not seen, bear out Korthals's description.

16. D. TRINERVIS, *Blume, Cat. Buitenz.* (1823) 78 cum tab., *et Bijdr.* (1825) 223, *et Fl. Javæ,* 11, tab. 1; *Dyer in* [*London*]

Journ. Bot. xii. (1874) 102; *Burck in Ann. Jard. Buitenz.* vi. (1887) 195.

Hill forests of West Java, 2000–3000 feet alt.

Leaves very large; secondary nerves 16–20 pairs; petiole $\frac{1}{4}$–$\frac{1}{6}$ the length of the blade. Fruit 1 in. in diam.

17. DIPTEROCARPUS HASSELTII, *Blume, Fl. Javæ* (1828–29), 22, t. 6.

Malacca (*Ridley*, n. 1032); "*Minyak Koring*, an important oil-tree"; Sumatra (*Forbes* n. 3196); hill-forests of West Java; Luzon (*Cuming*, n. 881) (Vidal, Pl. Vasc. Filip. p. 60). A much more widely distributed species than *D. trinervis*.

Leaves (and flowers) much smaller than those of *D. trinervis*; secondary nerves 10–14 pairs; petiole $\frac{1}{3}$–$\frac{1}{4}$ the length of blade. Fruit $\frac{3}{4}$ in. in diam., the calyx-tube much constricted at the top.

Dyer unites *D. trinervis* and *D. Hasseltii*; but Hance (in [London] Journ. Bot. xvi. (1876) 241) and Burck keep them separate.

18. D. RETUSUS, *Blume, Cat. Buitenz.* (1823) 77, *et Verhand. Bat. Genootsch.* ix. 178, *et Bijdr.* v. 223, *et Fl. Javæ*, 14, t. 2; *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 102; *Burck in Ann. Jard. Buitenz.* vi. (1887) 197.—D. Spanoghei, *Blume, Fl. Javæ*, (1828–29) 16, t. 3; *Burck in Ann. Jard. Buitenz.* vi. (1887) 198.

Hill-forests of West Java, 2000-3000 feet alt.

Hoary; stipules and petioles with long hairs; secondary nerves 18–24 pairs. Wings of fruiting-calyx large, broader in the upper part, with scattered stellate hairs.

Burck separates *D. Spanoghei* from *D. retusus*.

19. D. GRACILIS, *Blume, Bijdr.* v. (1825) p. 224, *et Fl. Javæ*, 20, t. 5; *Burck in Ann. Jard. Buitenz.* vi. (1887) 196.

Forests of West Java.

Pubescent. Leaves small, ovate-lanceolate; secondary nerves 10–12 pairs, stellate pubescent beneath. Fruit $\frac{3}{4}$ in. in diam.; wings of fruiting-calyx hairy.

20. D. LITTORALIS, *Blume, Bijdr.* v. (1825) 224, *et Fl. Javæ*, 17, t. 4; *Burck in Ann. Jard. Buitenz.* vi. (1887) 198.

Rocky coast of East Java, and on the small island Nusa Kambangan.

Glabrous, except stipules. Secondary nerves 18–20 pairs. Wings of fruiting-calyx very large, minor segments small.

Beccari n. 2915, from Borneo, is similar, but has smaller leaves, and the longer segments of the fruiting-calyx are oblanceolate.

21. DIPTEROCARPUS CANCANUS, *Burck in Ann. Jard. Buitenz.* vi. (1887) 196.

Bangka.

22. D. LAMPONGUS, *Scheffer in Nat. Tidschr. Nederl Ind.* xxxi. (1870) 346; *Burck in Ann. Jard. Buitenz.* vi. (1887) 197.

Sumatra.

D. *Philippine Islands.*

23. D. VERNICIFLUUS, *Blanco, Fl. Filip.* ed. II. (1845), 314, *et ed. Naves*, ii. (1878), 217, t. 183; *Vidal, Sinopsis, Atlas* (1883), t. 14 B, *et Pl. Vasc. Filip.* 59.—D. turbinatus, *Villar in Blanco Fl. Filip. Nova Append.* 20.

Luzon.

Leaves membranous, elliptic-oblong, acuminate; midrib and secondary nerves (14 pairs) clothed when quite young with very long whitish hairs, some of which remain on the adult leaf; petioles long, $\frac{1}{3}$–$\frac{1}{4}$ the length of blade. Calyx 4–5-angled. Anthers subulate but not aristate (*Blanco*). Fruit globose, constricted at apex, not angled.

24. D. VELUTINUS, *Vidal, Pl. Vasc. Filip.* (1886) 59.

Luzon (*Vidal*, nn. 80, 81, 2163).

25. D. AFFINIS, sp. nova. Arbor, ramulis petiolisque pube stellata tomentosis. Folia submembranacea oblanceolata repanda, subtus ad costam pilis longis obsita, stipulis linearibus tomentosis petiolo duplo longioribus. Flores magni, breviter pedicellati. Calyx tubo crasse coriaceo turbinato lævi glaberrimo, laciniis linearibus 2 tubum æquantibus, 3 reflexis brevibus. Ovarium, stylopodium cum styli parte inferiore pilosa. Fructus ignotus.

Luzon, Prov. Camarines (*Vidal*, n. 82) (" sp. affinis *D. piloso*, Vidal, Pl. Vasc. Filip. 60). Ticao Island (*Vidal*, 2161).

Blade 11–13 in. long; petiole $1\frac{1}{2}$ in. Secondary nerves 24–28 pairs, straight, bent near margin, and terminating in reticulate intramarginal veins. Tertiary nerves parallel and reticulate. The pubescence of branchlets, petiole, and midrib consists of tufts of stellate hairs unequal in length, some short, others very long. It is quite the pubescence of *D. pilosus*, the difference between the two species consisting in the narrow membranaceous leaves

and the glabrous calyx of *Dipterocarpus affinis*, the smaller segments in flower reflexed, and not erect as represented in Korthals's figure of *D. Baudii*. Vidal, Sinopsis, Atlas, tab. 14. fig. D, represents a fruit of what he calls *D. pilosus*, from the island Alabat (Tayabas), with the smaller segments of the fruiting-calyx erect, which agrees with the fruit of *D. pilosus* from Assam and of *D. Baudii* from Sumatra.

A leaf of *D. elongatus*, Korthals, flowers and fruit of which are unknown, from Borneo in Herb. Kew, agrees well with *D. affinis*, and it is not impossible that more complete specimens of the two species may show their identity, in which case Korthals's name will take precedence.

Sect. II. Tuberculati, *Dyer*.

Tube of fruiting-calyx with 5 protuberances in its upper portion.

26. Dipterocarpus tuberculatus, *Roxb. Hort. Beng.* (1814) 93, *et Fl. Ind.* ii. 614; *Dyer in Hook. f. Fl. Brit. Ind.* i. 297; *Kurz, For. Fl. Brit. Burma*, i. 113; *Pierre, Fl. For. Cochinch.* fasc. 14, t. 218.

Through the whole Eastern Peninsula to N. lat. 25°, from Pegu to Cambodia. Eminently gregarious, forming extensive forests on laterite at the foot of the lower hills of Pegu, Tenasserim, Siam, and the southern districts of Upper Burma, accompanied by a few subordinate species, such as *Terminalia*, *Eugenia*, *Dillenia*, and *Symplocos*.

27. D. cornutus, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 296; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 93.

Penang, Perak, Malacca, Pahang, Singapore, probably all over the Malay peninsula.

28. D. Warburgii, sp. nova. Arbor. Folia chartacea, elliptica, glaberrima, margine undulata, costa nervisque secundariis (utrinque 20) valde conspicuis, tertiariis plurimis parallelis et reticulatis obscuris. Flores .... Fructus apice 5-cornutus, in tubum calycinum brevem constrictus, alis late linearibus a basi 5-nerviis, nervis 3 validioribus.

Mindanao, Philippine Islands, in a narrow plain along the coast at Batangan near Davao, in dense evergreen mixed forest, associated with other Dipterocarps, *Myristica*, and Anonaceæ (*Warburg*, n. 14431).

Blade 7–9 in. long; fruit 1 in.; wings 4–5 in. long, 1 in. broad. Differs from *Dipterocarpus cornutus* by the glabrous leaves and the narrow neck above the fruit, formed by the short calyx-tube. Vidal ('Sinopsis,' plate 14 C) represents a fruit somewhat resembling this species. It is called there *D. turbinatus*, and is said to have been brought from the island of Ilo-Ilo (Panay), which is situated halfway between the main portion of Luzon and Mindanao. The fruit of *D. turbinatus* from the Andamans and Malacca is also constricted at the apex, but it is more globular than the elongated fruit of this species, which, moreover, has 5 protuberances alternating with the segments of the fruiting-calyx.

Sect. III. Angulati, *Dyer*.

Tube of fruiting-calyx pentangular.

A. *Ceylon.*

29. Dipterocarpus zeylanicus, *Thw. Enum. Pl. Zeyl.* (1859) 33; *Trimen, Fl. Ceylon,* i. 114, t. 10.

B. *Eastern Peninsula.*

30. D. fagineus, *Vesque in Compt. Rend.* lxxviii. (1874) 625; *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 94.—D. prismaticus, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 105, 152, t. 144. fig. 17.

Penang; Perak; Borneo (*Motley*, n. 143; *Beccari*, n. 3008).

31. D. Dyeri, *Lanessan, Pl. Utiles Col. Fr.* (1886) 297; *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), tt. 216, 217.

Cochinchina.

Yields as much wood-oil as *D. alatus*; timber highly esteemed (*Pierre*).

C. *Borneo.*

32. D. globosus, *Vesque in Compt. Rend.* lxxviii. (1874) 627. —D. Beccarianus, *Vesque in Compt. Rend.* lxxviii. (1874) 627.—D. Beccarii, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 103, t. 144. fig. 16.

Borneo (*Beccari*, nn. 2914, 2915).

33. D. geniculatus, *Vesque in Compt. Rend.* lxxviii. (1874) 626.—D. angulatus, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 104.

Borneo (*Beccari*, n. 3034).

Supposed by Dyer to be allied to *Dipterocarpus vernicifluus*, Blanco; it differs, however, by the coriaceous glabrous leaves, the absence of long hairs along the midrib and secondary veins, and the pentangular fruit.

34. DIPTEROCARPUS APPENDICULATUS, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 347; *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 104; *Burck in Ann. Jard. Buitenz.* vi. (1887) 200.—D. acutangulus, *Vesque in Compt. Rend.* lxxviii. (1874) 626.
Bangka; Borneo (*Beccari*, n. 2913).

35. D. PENTAGONUS, *A. DC. in DC. Prodr.* xvi. pars 2 (1864), 610; *Burck in Ann. Jard. Buitenz.* vi. (1887) 199.
Borneo.

Sect. IV. ALATI.

Tube of fruiting-calyx with 5 straight wings.

A. *Ceylon and Western Peninsula.*

36. D. SCABRIDUS, *Thw. Enum. Pl. Zeyl.* (1859) 34; *Trimen, Fl. Ceylon*, i. 115.
Ceylon.

37. D. GLANDULOSUS, *Thw. Enum. Pl. Zeyl.* (1859) 34; *Trimen, Fl. Ceylon*, i. 115.
Ceylon.

38. D. INSIGNIS, *Thw. Enum. Pl. Zeyl.* (1859) 34; *Trimen, Fl. Ceylon*, i. 116.
Ceylon.

39. D. BOURDILLONI, *Brandis in Hook. Ic. Pl.* tab. 2403.
Evergreen forest on the Periyar river in North Travancore (*Bourdillon*); Carcoor ghat, Malabar (*Brandis*, 1868).

This species seems to be limited to the southern districts, between the Ghats and the coast, in the Western Peninsula of India; while *D. indicus*, Beddome, is found in all districts from North Canara to Travancore. *D. Bourdilloni* is closely allied to *D. insignis*, Thw., of Ceylon, while *D. indicus* is very near *D. turbinatus* of the Eastern Peninsula.

B. *Eastern Peninsula.*

40. D. ALATUS, *Roxb. Hort. Beng.* (1814) 42, *et Fl. Ind.* ii. 614; *Pierre, Fl. For. Cochinch.* fasc. 14, t. 212; *King in Journ.*

Asiat. Soc. Bengal, lxii. pars 2 (1893), 98.—Dipterocarpus Lemeslei, *Vesque in Compt. Rend.* lxxviiii. (1874) 626.

Pegu; Tenasserim; Siam; Cambodia; Cochinchina, where, according to Pierre, it is found from the coast to an elevation of 1800 feet. Not gregarious, but scattered in mixed, partly evergreen forests, often taller than these. Yields large quantities of wood-oil, which in the wood is found chiefly in the long horizontal cells of the medullary rays, which are up to 3 mm. (0·12 in.) long.

Wings of calyx-tube broad.

41. Dipterocarpus costatus, *Gaertn. f. Fruct.* iii. (1805) 50, t. 187; *Ham. in Mem. Werner. Soc.* vi. (1832) 299; *Kurz in Journ. Asiat. Soc. Bengal*, xliii. pars 2 (1874), 98, *et For. Fl. Brit. Burma*, i. 117; *King in Journ. Asiat. Soc. Bengal*, p. 99 in obs.

South Tipperah near the coast (*Hamilton*); Pegu; Martaban; Tenasserim.

Wings of calyx-tube narrow.

I follow King in keeping *D. costatus* separate from *D. alatus*, because the original specimens of fruit preserved in the British Museum, upon which Gaertner based his species, actually have very narrow wings, and because King mentions specimens from Burma with fruits exactly like that figured by Gaertner. I am not, however, sure whether this character is constant. This question must be studied on the spot in the forest. Specimens of *D. costatus* from Tipperah or Chittagong I have never seen.

42. D. incanus, *Roxb. Hort. Beng.* (1814) 42, *et Fl. Ind.* ii. 614; *Kurz in Journ. Asiat. Soc. Bengal*, xliii. pars 2 (1874), 98, *et Fl. Brit. Burma*, i. 113 (clav. analyt.); *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 97.

Common on South Andaman; Pegu; Tong kah (Siam), on the east coast of the Malay peninsula in its northernmost extremity (*Curtis*, n. 2926). Roxburgh describes *D. incanus* from Chittagong, which I think is outside its area of distribution. I doubt whether Roxburgh had before him the plant which we now call *D. incanus*, Roxb. But as no authentic specimens appear to be in existence, this cannot be proved, and under these circumstances Roxburgh's name had better be permitted to stand.

43. D. scaber, *Ham. in Mem. Werner. Soc.* vi. (1832) 300; *Dyer in Hook. f. Fl. Brit. Ind.* i. 297.

Mountains in South Tipperah (*Hamilton*).

A most remarkable species. The specimen preserved in the

British Museum under this name has leaves somewhat resembling *Dipterocarpus pilosus*, but much smaller. The small winged fruit is detached, but has the same kind of hairs as the leaves. The wings of the calyx-tube are narrow. Has this specimen really come from Tipperah?

It may be useful here briefly to review the 4 species described by Dr. Francis Hamilton in Mem. Wernerian Society, vi. p. 298, all from Tipperah (Tripura)—*D. lævis*, Ham., and *scaber*, Ham., on the hills; *D. costatus*, Gaertn. f., and *turbinatus*, Gaertn f., near the coast. His paper was read in 1825, but was not published until 1832. Two of these species, *D. scaber* and *costatus*, have the fruiting-calyx 5-winged; while in *D. lævis* and *turbinatus* the calyx-tube is smooth, without wings. Hamilton states that *D. costatus* and *D. lævis* produce wood-oil and are consequently called *Telia Gurjun*, while *D. scaber* and *D. turbinatus* only produce wood and are called *Dulia Gurjun*.

In 1814 Roxburgh had enumerated in his 'Hortus Bengalensis,' and described in the 'Flora Indica,' the MSS. of which he left at the Gardens when he went to Europe that year, three species from Tipperah and Chittagong, viz.:—one with unwinged fruit, *D. turbinatus*, Gaertn. f., as *Telia Gurjun*, and two with winged fruit, viz. *D. costatus*, Gaertn. f., with linear-oblong leaves (*Telia Gurjun*), and *D. incanus*, Roxb. (*Gurjun*). The latter, he reports, is said to furnish the largest proportion of the best sort of wood-oil. The tree described by Roxburgh as *D. costatus*, Gaertn. f., Wight and Arnott (Prodromus Fl. Penins. Or. p. 84) called *D. angustifolius*. This, however, is merely a name, which need not trouble us any further. When Dr. Hamilton wrote his paper in 1825, he had possibly seen neither the 'Hortus Bengalensis' nor the MSS. of Roxburgh's 'Flora Indica,' which was not printed until 1832.

The probability is, that besides *Dipterocarpus pilosus* there is only one species with unwinged fruit in the Chittagong and Tipperah district, viz. *D. turbinatus*, as here defined, and only one species with winged fruit. This latter may, or may not, turn out to be Hamilton's *D. scaber*, and it may possibly prove to be identical with what Roxburgh described as *D. incanus*. Researches on the spot in the forest alone can clear up this knotty but interesting question. All species of *Dipterocarpus* yield wood-oil; and Dr. Hamilton's account of one winged and one unwinged species yielding wood-oil, while the other two only yield wood, need not be seriously taken into consideration.

44. Dipterocarpus Griffithii, *Miq. Ann. Mus. Lugd.-Bat.* i. (1863–64) 213; *Dyer in Hook. f. Fl. Brit. Ind.* i. 299; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 96.

South Andaman; Mergui; Pahang, on the east side of the Malay Peninsula, *Ridley* (Trans. Linn. Soc. ser. 2, Bot. iii. (1893) 283).

45. D. grandiflorus, *Blanco, Fl. Filip.* ed. ii. (1845) 314, *et ed. Naves*, ii. (1878) 218, t. 263; *Vidal, Sinopsis, Atlas* (1883), t. 14 A, *et Pl. Vasc. Filip.* 59; *Burck in Ann. Jard. Buitenz.* vi. (1887) 201; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 95.—D. Motleyanus, *Hook. f. in Trans. Linn. Soc.* xxiii. (1860) 159.—D. pterygocalyx, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 347; *Dyer in Hook. f. Fl. Brit. Ind.* i. 298.

Malacca; Penang ("*Kayu minyak*," Curtis); Perak; Johore (attains 200 feet, *Cautley*); Bangka (*Teysmann*); Labuan, Borneo (*Motley*); Luzon, Philippine Is. (*Cuming*, n. 1073; *Vidal*, n. 986).

46. D. Kunstleri, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 96.

Perak.

47. D. oblongifolius, *Blume, Mus. Bot.* ii. (1852) 36; *Burck in Ann. Jard. Buitenz.* vi. (1887) 201; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 95.—D. pulcherrimus, *Ridley in Trans. Linn. Soc.* ser. 2, *Bot.* iii. (1893) 283.

Perak; Pahang (*Ridley*, n. 2582); Java (*Horsfield*; Mus. Brit.); Sumatra; Borneo (*Korthals*; *Beccari*, n. 3417, n. 3762; *Haviland*, n. 1638).

Ridley's specimens from Pahang agree exactly with those from Perak and Borneo. As already noticed by King, the Malayan specimens are glabrous except inflorescence, while in the Borneo specimens young shoots, buds, and petioles are tomentose.

48. D. artocarpifolius, *Lanessan, Pl. Utiles Col. Fr.* (1886) 297; *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), t. 213 A.

Cochinchina.

49. D. insularis, *Hance in* [*London*] *Journ. Bot.* xiv. (1876) 241; *Pierre, Fl. For. Cochinch.* fasc. 14, t. 214 A, B.

Cambodia; Cochinchina.

C. *Sumatra and Borneo.*

50. D. validus, *Bl. Mus. Bot.* ii. (1852) 36; *Burck in Ann. Jard. Buitenz.* vi. (1887) 202.

Sumatra (*Forbes*); Borneo (*Korthals*).

Large tufts of long thin hairs densely covering buds and young shoots. Leaves thickly coriaceous, glabrous, very large, up to 25 in. long and 12 in. broad, elliptic-oblong or obovate, obtuse at both ends. Secondary nerves 22–24 pairs, very prominent on the underside, straight, terminating in conspicuous intramarginal veins. Tertiary nerves parallel, not conspicuous. Petiole 2½ in. long. Flowers large, 2½ in. long, distichous in simple racemes, the two larger calyx-segments 1 in. long. Anthers with equal valves, at base auriculate; connective terminating in a stout, at the base 4-sided acumen, a little longer than the anther. Ovary glabrous; stylopodium hirsute with long hairs; style very short, glabrous.

Dyer (Journ. Bot. 1874, pp. 108, 153) is disposed to think that the large leaves of this species from Borneo preserved at Kew are from barren shoots of *Dipterocarpus Lowii*. But, as justly observed by Burck, the young shoots and stipules enclosing the buds of *D. Lowii* are clothed with an even velvety or silky tomentum. Excellent flowering specimens collected by Forbes in Sumatra, and preserved in the British Museum, settle the point beyond all doubt.

51. DIPTEROCARPUS MARGINATUS, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 64; *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 105; *Burck in Ann. Jard. Buitenz.* vi. (1887) 202.

Borneo.

52. D. NUDUS, *Vesque in Compt. Rend.* lxxviii. (1874) 626.—D. pentapterus, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 106.

Borneo (*Beccari*, nn. 2509, 2905).

53. D. STELLATUS, *Vesque in Compt. Rend.* lxxviii. (1874) 626.—D. nobilis, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 106.

Borneo (*Beccari*, nn. 2907, 2555).

Like *D. intricatus*, this species has often racemes in pairs, but they are not entirely unilateral, and in the specimens seen by me there is no pseudo-terminal flower in the bifurcation of the racemes.

D. *Philippine Islands.*

54. D. SPECIOSUS, sp. nova. Rami novelli pilis stellatis longis fasciculatis fuscis obtecti. Folia chartacea, breviter petiolata, oblongo-elliptica, subtus in costa pilis stellatis sparsis brevissimis

inspersa. Petioli pilis stellatis longis fasciculatis fuscis obtecti. Flores....... Fructus turbinatus, alis 5 crassis rigidis.

Island of Basilan, South Philippines (*Vidal*, n. 2160).

Blade 7–11, petiole $\frac{3}{4}$ in. long. Secondary nerves 18 pairs; tertiary parallel and reticulate. Differs from *Dipterocarpus grandiflorus* in the short petioles, the tomentum of long hairs on young shoots, and the thick, not membranous, edge of the fruit-wings.

Sect. V. Plicati, *Dyer* (slightly modified).

Margins of two adjoining fruiting-calyx segments, which are continued into the fruit-wings, remaining separate for some distance, uniting lower down and forming the 5 wings of the fruit. These wings are transversely plicate.

55. Dipterocarpus intricatus, *Dyer in [London] Journ. Bot.* (1874) 105; *Pierre, Fl. Forest Cochinch.* fasc. 14, t. 215.

Gregarious on sandy soil in the plains of Cochinchina. Delta of the Mekong river, 16 miles from the coast, extending to the limit of sweet and brackish water in the river (*Warburg*).

The inflorescence of this species is remarkable. Different from most other species of this genus, it consists of unilateral racemes, a pair of large oblong-falcate membranous 5-nerved bracteoles being at the base of the short pedicel, which stands in the axil of these bractlets. Two such racemes, each bearing 6–8 flowers, stand at the end of the peduncle, and the common peduncle apparently ends in a solitary terminal flower, which, however, is nothing but the lowest flower of one of the two collateral racemes. An examination of fresh specimens or material preserved in alcohol can alone settle this interesting point.

Contrary to Mr. Dyer's opinion (*l. c.* p. 153), I place *D. intricatus* under this section. In *D. lamellatus* the wings, decurrent from the margin of the two adjoining calyx-segments, unite at the base of the fruit, here they unite below the apex. The difference is only one of degree, pedicel and base of fruit in both species have 5 wings only.

56. D. lamellatus, *Hook. f. in Trans. Linn. Soc.* xxiii. (1860) 159; *Dyer in [London] Journ. Bot.* xii. (1874) 107, t. 145. fig. 22.

Borneo (*Motley*).

57. Dipterocarpus Lowii, *Hook. f. in Trans. Linn. Soc.* xxiii. (1860) 160; *Dyer in [London] Journ. Bot.* xii. (1874) 107, t. 145. fig. 23.—D. undulatus, *Vesque in Compt. Rend.* lxxviii. (1874) 626.
Borneo (*Lowe*; *Beccari*, n. 1267).

Flowers and fruit of the following species unknown.

58. D. elongatus, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 62; *Burck in Ann. Jard. Buitenz.* vi. (1887) 203.
Borneo.
[See p. 32 under *D. affinis.*]

59. D. balsamifer, *Blume, Mus. Bot.* ii. (1852) 37; *Burck in Ann. Jard. Buitenz.* vi. (1887) 203.
Borneo.

60. D. eurhynchus, *Miq. Fl. Ind. Bat. Suppl.* (1860) 485; *Burck in Ann. Jard. Buitenz.* vi. (1887) 203.
Bangka.

61. D. eurhynchoides, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 346; *Burck in Ann. Jard. Buitenz.* vi. (1887) 203.
Bangka.

62. D. fulvus, *Blume, Mus. Bot.* ii. (1852) 37.
Philippines.

63. D. Mayapis, *Blanco, Fl. Filip.* ed. ii. (1845) 313.
Philippines.
Villar (in Blanco, Fl. Filip. (ed. Naves et Villar) novissima Append. 20) reduces this to *D. turbinatus*, Gaertn. f.

64. Dipterocarpi sp., *Vidal, Pl. Vasc. Filip.* (1886) 60.
Philippines (*Vidal*, n. 1120).

2. Anisoptera, *Korthals, Verh. Natuurl. Gesch. Bot.* (1839–42), 65.

Trees, mostly large, with coriaceous, most of the Philippine species with chartaceous leaves. Stipules small, early deciduous. Young shoots, inflorescence, and underside of leaves clothed with fascicles of stellate hairs and minute round scales. Flowers shortly pedicellate, each in the axil of two caducous bracteoles, in racemes, which are not unilateral, these forming terminal and axillary, mostly drooping panicles. Calyx-segments slightly imbricate, often valvate, hairy, always outside, and generally also

inside. Petals longer than calyx-segments, puberulous outside. Stamens 20–35; anthers unequal valved, opening at the top, on short filaments; connective prolonged into a long awn. Stylopodium thick, fleshy, sometimes hollow, constricted at base or bell-shaped, generally puberulous, bearing 3, sometimes 4–6 short glabrous styles, rarely one short trifid style. Ovary partly immersed in the broad, somewhat concave receptacle, the edges of which expand, as the fruit ripens, into a globose or campanulate calyx-tube, which is adnate to the entire fruit or to the greater portion of it. Two segments of fruiting-calyx much larger than the others, with 3 prominent longitudinal nerves and numerous transverse veins. Hypocotyl enclosed by the fleshy bifid or reniform cotyledons.

In the circumference of the pith 18–24 resin-ducts, often large and close together. Three leaf-traces (one apical, two lateral) enter the petiole, the two lateral ones running in the bark, in some species through the entire internode, in others through the upper half of the internode only. The petiole under the insertion of the blade has a complete circle of 7–13 vascular bundles, which in some species are confluent, in others (*Anisoptera Curtisii*, Dyer) distinct; a resin-duct in the pith of each vascular bundle. No resin-ducts, or only a few, in the central mass of vascular bundles.

A well-defined genus, of which 15 species are known, 5 from the Eastern Peninsula of India, 3 from Borneo, 3 from the Philippine Islands, and 4 from New Guinea. *A. Curtisii* extends from the Malay Peninsula to Borneo.

A. *Eastern Peninsula.*

1. ANISOPTERA GLABRA, *Kurz, For. Fl. Brit. Burma*, i. (1877) 112; *Pierre, Fl. For. Cochinch.* fasc. 15, t. 235 B.

Evergreen forests on the east side of the Pegu Yoma and on the hills between rivers Sitang and Salween; Cambodia and Cochinchina.

Glabrous; leaves coriaceous; fruit ½ in. diam.; fruiting-calyx tube much constricted at the mouth, the 2 larger segments oblanceolate, the 3 nerves equally prominent, joined by conspicuous transverse veins at right angle.

At the British Museum are specimens from the State of Malacca (Mr. Ridley's collector, no. 841), in fruit, marked *A. glabra*, Kurz, by Dr. King, which fairly agree with Kurz's

description; the leaves, however, are not elliptically oblong to oblong, but oblanceolate and elliptic-lanceolate, with 12 p. arching secondary, and numerous, mostly very short intermediate nerves, distinct intramarginal veins, and a network of close venation between the secondary nerves. The underside of leaves is densely covered with minute round scales. Blade 3–4, petiole ¾ in. long. The specimens are glabrous, except the inflorescence which is pubescent, as well as the segments of the fruiting-calyx. The fruiting-calyx tube is only ⅓ in. diam., but is, like that of *Anisoptera glabra*, Kurz, much constricted at mouth. This may possibly be a new species. Good specimens in flower and fruit of *A. glabra*, Kurz, the *Thinkadoe* of Burmans, are required to decide this point.

2. ANISOPTERA OBLONGA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 301.—Shorea nervosa, *Kurz, For. Fl. Brit. Burma*, i. 119.

Tenasserim; Mergui.

Leaves coriaceous; young shoots, nerves of adult leaves beneath with fascicles of stellate hairs; stylopodium constricted at base, pubescent; 3 short glabrous styles. Fruiting-calyx campanulate, not much constricted at mouth, transverse veins of wings somewhat oblique. Branches of inflorescence often bifurcating, with a pseudoterminal flower in the bifurcation.

3. A. COCHINCHINENSIS, *Lanessan, Pl. Utiles Col. Fr.* (1886) 298; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 235 A.

Cochinchina.

Leaves coriaceous. Fl. large, ⅓ in. long; stylopodium constricted at base.

4. A. ROBUSTA, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 236.

Cochinchina.

Leaves coriaceous; young branchlets, petioles and inflorescence clothed with long stellate hairs. Stylopodium constricted at base.

The distinguishing characters of these 4 species are somewhat uncertain.

5. A. CURTISII, *Dyer, MS.*; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 100; *Engler, Natürl. Pflanzenfamilien*, iii. 6. tab. 122. fig. F.

Penang ("*Ringkong*," Curtis); Perak; North-west Borneo (*F. W. Burbidge*).

A species well marked by dense bright yellowish-brown tomentum, densely covering the underside of leaves, making the tertiary nerves indistinct. It consists of very minute round scales attached in the centre and a small number of dense tufts of short stellate hairs. Fruiting-calyx campanulate, not constricted at mouth. One of the longitudinal nerves of the larger segments is less distinct than the two others.

B. *Borneo.*

6. Anisoptera costata, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 67, t. 6. figg. 1–9; *Burck in Ann. Jard. Buitenz.* vi. (1887) 220.

Hills of South-east Borneo.

Leaves broadly elliptic, clothed beneath with tufts of stellate hairs and a dense tomentum of minute star-shaped scales. Secondary nerves 20–26 pairs; intramarginal veins and tertiary nerves very distinct. Tube and segments of fruiting-calyx tomentose. Cotyledons reniform (*Korthals*).

Specimens in leaf only, coll. by Motley and Barber in Borneo, somewhat resemble *A. costata* and *Curtisii*. Leaves oblong-elliptic, underside densely tomentose, sec. nerves 16–20, tertiary indistinct; stipules large, semipersistent.

7. A. marginata, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 66, t. 6. figg. 1 *a*–13 *a*.

Borneo: Bangarmarsing (*Motley*, n. 885, fl. white); Malay, "Rasak," but not the "Rasak" of Labuan. Labuan (*Motley*, n. 291). Hills of South-east Borneo, where this, like *A. costata*, grows gregariously, and is said to attain an immense height (*Korthals*). Bangka (*Teysmann*).

Glabrous, except youngest shoots and inflorescence. Leaves elliptic-oblong, second. nerves 10–14 pairs, tertiary mostly reticulate. Anthers mostly ciliate. At the top of pubescent stylopodium 3 short glabrous styles, which often cohere closely.

8. A. grandiflora, sp. nova. Arbor ingens. Folia obovato-elliptica, superne glabra, infra tenuiter velutina. Inflorescentia cum calycibus incano-tomentosa, floribus majusculis racemosis, pedicellis calycem dimidium æquantibus. Stamina 20–25. Pistillum stylopodio magno glabro, stylo brevi indistincte 3-dentato.

Garai, near Kuching (*Haviland*, n. 959).—Pl. II. fig. 29, Pl. III. fig. 1.

Blade 3–5 in., petiole $\frac{1}{2}$–$\frac{2}{3}$ in. long. Secondary nerves 10–12 pairs, tertiary parallel and reticulate. Fl. $\frac{2}{3}$ in. long; "petals pale, with odour of fungus" (*Haviland*). Fruit unknown.

C. *Philippine Islands.*

9. ANISOPTERA THURIFERA, *Blume, Mus. Bot.* ii. (1852) 42; *Vidal, Sinopsis, Atlas*, t. 14 E.—A. lanceolata, *Walp. Ann.* i. 113; *Engl. Natürl. Pflanzenfam.* iii. 6. t. 122, D, E.—Mocanera thurifera, *Blanco, Fl. Filip.* ed. i. (1837) 446.—Antherotriche lanceolata, *Turcz. in Bull. Soc. Mosc.* 1846 (pars 2), 506.—Dipterocarpus thurifer, *Blanco, Fl. Filip. ed. Naves*, ii. (1878) 212, t. 264.—Pl. II. fig. 28.

Prov. Albay, Luzon (*Cuming*, n. 882); Antipolo district, Morong, Luzon (*Vidal*, n. 83); Capas, prov. Farlae, Luzon (*Vidal*, n. 87).

Youngest parts, inflorescence, petioles, and nerves on underside of leaves with minute round scales and sparse stellate hairs. Leaves elliptic, shortly acuminate, thinly chartaceous, on long petioles; blade 4–5, petioles 1$\frac{1}{2}$ in. long. Secondary nerves 10–16 pairs, alternating with shorter intermediate nerves. Tertiary nerves parallel, joined by closely reticulate veins. Panicles drooping; fl. on pedicels shorter than half calyx, each fl. supported by two oblong, somewhat unequal, 1–5-nerved bracteoles. Anthers glabrous, the awn longer than anther. Stylopodium bell-shaped, pubescent, sometimes slightly constricted above ovary. Fruit globose, $\frac{1}{2}$ in. diam., not much constricted at top.

10. A. VIDALIANA, sp. nova. Arbor, novellis tenuissime lepidotis. Folia coriacea, elliptica vel elliptico-oblonga, fere glaberrima, nervis secundariis utrinque 14–18, nervis tertiariis parallelis et reticulatis, intramarginalibus conspicuis. Inflorescentia puberula, paniculis nutantibus, pedicellis calycem dimidium superantibus. Calycis segmenta vix imbricata, extus pilis stellatis, intus pilis simplicibus tomentosa. Petala oblonga, acuta, apice extus puberula. Stamina 35, antheris glabris aristâ duplo longiore. Ovarium semisuperum (cum stylopodio crasso basi constricto) pilosum; stylis 3, glabris. Fructus parvus, turbinatus, calycis segmentis 2 majoribus oblanceolatis obliquis, 3 minoribus linearibus 1–3-nerviis.

Caraballo Mountains (*Vidal*, n. 73); San Mateo, Manila

(*Vidal*, n. 85); Antipola (*Vidal*, n. 651); Prov. Manila (*Vidal*, n. 2158). All these in Luzon. Island of Cebu (*Vidal*, n. 2165; not the fruit, which is that of a *Parashorea*). Vidal (Pl. Vasc. Filip. 60, 61) refers n. 73 to *Vatica*, n. 85 to *A. oblonga*, and n. 651 to *A. thurifera*.

Blade 2½–7, petiole ½–1 in. long. Fl. ⅓ in. long; wings of fruiting-calyx 3–4 in. long, small segments ½–1 in. long.

11. Anisoptera tomentosa, sp. nova. Arbor, ramulis petiolisque a pilis stellatis longiusculis tomentosis. Folia elliptica vel elliptico-oblonga, coriacea, nervis infra a pilis stellatis longiusculis tomentosis, secundariis utrinque 12–14 subtus valde prominulis, intra marginalibus conspicuis, tertiariis parallelis et reticulatis. Flores . . . . Fructus magnus, globosus, tubo calycino apice valde constricto, laciniis tomentosis 2 majoribus lineari-spathulatis apice obtusis venis transversis valde obliquis 3 minoribus linearibus acutis.

Bosoboso, distr. Morong, Luzon, *Vidal*, n. 86 (*A. oblonga*, Pl. Vasc. Filip. 60).

Blade 3½–4½ in., petiole ¾–1 in. long, fruit ½ in. diam.; larger segments of fruiting-calyx 4 in. long.

D. *New Guinea.*

12. A. polyandra, *Blume, Mus. Bot.* ii. (1852) 42, t. 6.

13. Anisopteræ sp., *Dyer in* [*London*] *Journ. Bot.* xvi. (1878) 99.

Mount Arfak, *Beccari* (not seen).

14. A. parvifolia, *Warburg in Engler's Bot. Jahrb.* xiii. (1890–1) 382.

A small tree near the coast of Sigar, McClure's Gulf, German New Guinea.—[Not seen.]

15. A. Forbesii, sp. nova. Arbor magna. Folia coriacea, glabra, e basi cordata vel rotundata late elliptica, apice acutiuscula vel obtusa, nervis secundariis utrinque 8–10 robustis arcuatis, nervis tertiariis plerumque reticulatis, intramarginalibus valde conspicuis. Fructus in racemis elongatis terminalibus et lateralibus interdum ramosis, racemorum rachibus pedicellis (necnon calycibus fructiferis) pubescentibus. Calycis fructiferi tubus hemisphæricus fructum ultra dimidium tegens, segmentis

2 majoribus oblanceolatis 3-nerviis venis transversis parum obliquis.

New Guinea; Sogeri region, 2000 ft. alt. (*H. O. Forbes*, n. 373).

The blade of leaf is 4 in. long, $2\frac{1}{2}$ in. broad; petiole $\frac{3}{4}$ in. long. Fruit finely but densely tomentose, apiculate, crowned by the indurated stylopodium and 3–4 styles. Larger segments of fruiting-calyx 3 in., smaller $\frac{3}{4}$ in. long, tube $\frac{1}{4}$ in. diam. Seed apparently not quite ripe, radicle short, cotyledons reniform, the outer flat, concave, enclosing the inner, which is folded and crumpled. By the shape of leaves, the campanulate fruiting-calyx, and the structure of the seed this species is closely allied to *Anisoptera costata*, Korthals, which, however, has leaves pubescent beneath. *A. polyandra*, Blume, also has a campanulate fruiting-calyx, but one of the 3 longitudinal nerves of the larger segments is close to the margin, and the smaller segments are much smaller. Moreover, the leaves are described by Blume as "ovalia vel ovali-oblonga." The unnamed species described by Dyer has a yellow pubescence of fruiting-calyx similar to this species, but the calyx-tube is described as spheroidal.

II. DRYOBALANOPSEÆ.

3. Dryobalanops, *Gaertn.*; *Engler, Natürl. Pflanzenfamilien*, iii. 6. 258, Fig. 120. (Plate I. figs. 1–6.)

(Including *Baillonodendron*, Heim.)

The external characters of this genus are well known; the internal structure is, as previously mentioned, so peculiar, that I desire to discuss it at some length. Through the pith of a leaf-bearing branch runs a main resin-duct, and this main duct gives off branches, which enter the petioles and axillary buds. The process may be most easily explained by reference to *D. lanceolata*, Burck. A series of transverse sections made at different points of an internode is represented on Plate I., the levels at which the sections were made being indicated on that internode (fig. 17). These sections are a selection from many hundreds which were made and examined, when studying the course of leaf-traces and resin-ducts in that internode. Fig. 118 (C, D, E, F) of Engler's Natürl. Pflanzenfamilien, iii. 6, may also be referred to. Fig. 1 represents the base of the internode and of a side branch still attached to it. In both cases the main

resin-duct occupies the centre of the pith, but in the main axis 2 lateral leaf-traces, with a resin-duct in the pith of each, are on the point of separating from the central cylinder, that on the left side being in advance of the other. On fairly well preserved herbarium specimens the cortical leaf-traces can often be seen on the outside, and this is the case in the internode represented in fig. 17. In the main axis two cortical leaf-traces enter the bark at the base of the internode, and continue in the bark through the entire length of it, until they enter the petiole. In the side branch the lateral leaf-traces separate from the central cylinder at a higher level. Higher up (fig. 2) the lateral leaf-traces have entirely separated from the central cylinder, and the main resin-duct in the pith has bifurcated. Before a resin-duct bifurcates, its diameter is always enlarged in the direction of the bifurcation. Of the two branch-ducts, that towards the apex of the pith shows such an enlargement, and consequently, in fig. 3, it has subdivided—one smaller branch-duct having entered the apical or median leaf-trace now in course of separation from the central cylinder. At the same time the duct in the opposite half of the pith is in the act of bifurcation, and fig. 4 shows that it has actually divided itself into 3 branches, but in a direction at right angles to the longer axis. Of the 7 ducts shown in that figure, those in the apical and in the two lateral leaf-traces enter the petiole, as shown in fig. 5—the one in the upper portion of the pith enters the axillary bud, while the 2 lateral ones in the lower portion are destined to enter the lateral leaf-traces of the petiole at the top of the next higher internode. In fig. 5 these lateral resin-ducts have entered the wood, the medullary rays starting from that point having arranged themselves in a fan-shaped manner. This preparatory arrangement of the medullary rays can already be distinguished at a lower level, as indicated in fig. 4. Fig. 118 D (Engler) represents a section intermediate between figs. 2 and 3, while F shows a section intermediate between figs. 4 and 5.

In fig. 5 the petiole is still attached to the branch, the vascular bundles of the three leaf-traces having arranged themselves in a complicated central vascular cylinder, and it will be noticed that while the apical resin-duct, which is on the underside of the petiole, remains undivided, the two lateral ones have each bifurcated, so that the petiole at its base has 5 resin-ducts. Three of these are situated in the bands of pith, which run through

the irregular masses of xylem and phloëm that constitute the central cylinder, while two on the edges in the underside of the petiole are situated outside the central cylinder. This remarkable peculiarity—that some of the resin-ducts in the petiole are outside the central cylinder—is found in all species of this genus, as far as they have been examined. Fig. 6 is a section of the petiole, a short distance above its base.

These 5 resin-ducts continue through the entire length of the petiole to the base of the blade and into the midrib. In the mass of xylem and phloëm, with pith between them, which forms the central cylinder at the base, two portions may be distinguished—viz., on the underside of the petiole a semicircle of xylem with a belt of phloëm on the outside, and pith on the inside, the latter enclosing a large resin-duct; and secondly, on the upper side of the petiole straight bands of xylem and phloëm with pith between, bent downward at the ends, so as to overlap the semicircle on the underside. Enclosed in this mass near the ends are the two upper ducts, while the two lower resin-ducts are outside the central mass of vascular bundles. Below the base of the blade there is on the underside an outer semicircle, though here and there interrupted, of xylem with a belt of phloëm on the outside, in the pith of which is always the central resin-duct, and sometimes also two of the lateral ducts, while the two others are always outside the central cylinder. The semicircle is closed, but not completely, by a bar of xylem with phloëm on the outside. A ring is thus formed, and this ring encloses several curved bands of xylem, each with a belt of xylem on the underside, the opening of the curve looking towards the upperside of the petiole.

Broadly speaking, the structure here described of *D. lanceolata* represents the structure of all species, as far as known, with some variations, which will now briefly be noted. In *D. aromatica* the base of the internode generally has one main resin-duct in the centre of the pith, which sends out branches at a higher but varying level. In some cases, however, the main duct has already divided at the base of the internode, so that in these cases 2 or 3 ducts appear at that point. The lateral leaf-traces enter the bark at varying levels, in some cases above the middle of the internode. After the branch-ducts, which are destined for the apical leaf-trace and for the axillary bud, have separated from the main duct, this subdivides, sending off, first one, then a second branch for the lateral leaf-traces of the next

higher internode; this subdivision, however, does not take place in as regular and, so to say, elegant a manner as is the case in *Dryobalanops lanceolata*.

For the petiole of *D. aromatica,* Burck claims a very remarkable feature, viz., that the 4 lateral ducts do not run through the entire length of the petiole, but lose themselves gradually in the intercellular spaces of the tissue, so that the ducts, which accompany the lateral nerves in the leaf, all branch off from one central resin-duct. This I am not able to confirm. Some of the lateral ducts are often indistinct, but, as a rule, I have been able to trace them through the entire length of the petiole. Nor am I able to agree with Burck's statement, endorsed by Heim, that in *D. aromatica* at the base of the petiole the curved band of vascular bundles is open towards the underside ("une courbe ouverte vers le côté inférieur du pétiole"). The large resin-duct, which occupies the underside of the petiole, is surrounded below by a semicircle of xylem with an outside belt of phloëm, and the opening of this semicircle is towards the upperside of the petiole. However, the upper portion of the intricate mass of vascular bundles overlaps the semicircle mentioned on both sides, and this has perhaps given rise to the opinion that *Dryobalanops aromatica* forms an exception to the general rule in regard to the structure of the petiole.

It may here be mentioned that in all essential points the petiole of the three species examined by me—*lanceolata*, *aromatica*, and *oblongifolia*—has the same structure, at the base as well as below the insertion of the blade.

D. oblongifolia, Dyer, agrees with *D. lanceolata,* Burck, in this, that the lateral leaf-traces separate from the central cylinder below the base of the internode. At the base, above the insertion of the axillary bud, there are, beside the two cortical leaf-traces with a duct in each, as correctly observed by Heim, two large resin-ducts in the middle of the pith; but these ducts are contiguous and are only divided by a narrow bridge. The fact is, that the main central resin-duct begins to divide a little below the base, at the level of the axillary bud, just as is occasionally the case in *D. aromatica.* The formation of branch resin-ducts, higher up the internode, progresses in a manner similar to what takes place in *D. aromatica,* one branch-duct entering the apical leaf-trace, which with the two cortical ones forms the petiole, while a second enters the axillary bud, and two

more enter the lateral leaf-traces destined for the next higher internode.

The material for examining internode and petiole of *Dryobalanops oblongifolia* I owe to the liberality of the British Museum, while in regard to *D. lanceolata* and *aromatica* I am indebted to the Royal Botanical Museum at Berlin. For *D. Beccarii* I have not had material for examination.

The essential anatomical characters of the genus, as far as known, are:—One main duct in the middle of the pith, which sends out branch ducts into the lateral and apical leaf-traces as well as into the axillary bud; two lateral leaf-traces in the bark, separating from the central cylinder at the base or in the middle of the internode. The pith consists of one class of cells with thickened walls in *D. lanceolata*; of two classes, thick-walled and thin-walled cells, in the two other species. In the outer bark are, in all three species, two classes of sclerenchymatic cells, circular with the walls thickened all round, and horseshoe-shaped cells, with the inner wall only thickened.

A small genus, only four species known at present, one from the Malay Peninsula, Sumatra, and Borneo, and perhaps some of the South Philippine Islands, the other three from Borneo.

1. Dryobalanops aromatica, *Gaertn. f. Fruct.* iii. (1805) 49, t. 186; *Burck in Ann. Jard. Buitenz.* vi. (1887) 243—D. Camphora, *Colebr. Asiat. Research.* xii. 535.

Sumatra (where, according to Korthals, it grows gregariously); Lingga; Borneo. According to Vidal, 'Sinopsis de plantas leñosas,' p. 48, also probably on Balabac and other Philippine islands. Mr. Ridley tells me that the tree grows in some quantity on the river Indau in the northern part of Johore, Malay Peninsula, and that the natives obtain oil and camphor from it.

Leaves ovate, long acuminate; cup of fruiting-calyx enclosing half or more than half of the fruit; segments lanceolate, obtuse, 7–9-nerved. Fruit ovoid.

2. D. Beccarii, *Dyer in* [*London*] *Journ. Bot.* xii. (1874) 100, t. 142. figg. 6, 7; *Burck in Ann. Jard. Buitenz.* vi. (1887) 243.

Borneo (*Beccari*, nn. 2553, 2944) (2994, *Burck*).

Leaves elliptic, shortly acuminate; cup of fruiting-calyx small, enclosing only base of fruit; segments linear-spathulate, prominent oblique and ramified veins joining the 9 longitudinal nerves. Fruit ovoid, with numerous raised lines.

3. Dryobalanops lanceolata, *Burck in Ann. Jard. Buitenz.* vi. (1887) 224, t. 29. fig. 6.

Borneo.

Leaves lanceolate; cup of fruiting-calyx small, enclosing only base of fruit. Fruit globose, with numerous raised lines.

4. D. oblongifolia, *Dyer in [London] Journ. Bot.* xii. (1874) 100, t. 142. figg. 8–12; *Burck in Ann. Jard. Buitenz.* vi. (1887) 244.—Baillonodendron malayanum, *Heim in Bull. Soc. Linn. Paris*, ii. (1890) 867, *et Recherch. Diptérocarp.* 83.

Borneo (*Beccari*, nn. 2533, 3734, 2993).

Leaves elliptic-oblong, very shortly acuminate. Branches of inflorescence and calyx clothed with minute stellate hairs. Cups of fruiting-calyx enclosing the base of the fruit only, funnel-shaped; segments short, thickly coriaceous, reflexed at apex. The structure of flower and seed corresponds with that of the other species. Heim bases his new genus *Baillonodendron* upon the nervation of the leaves and anatomical characters; neither, however, present anything peculiar. The fruit is on a stalk (Heim), which is unusual in this order, but does not justify a separate genus. The stalk, which I have not been able to examine, seems analogous to that of *Shorea platycarpa*, Heim. The fainter intermediate nerves alternating with the secondary nerves are also found in the other species. The hispid inflorescence and calyx are peculiar, but this only constitutes a specific difference.

III. SHOREÆ.

4. Doona, *Thw.*

The essential characters of this remarkable genus are well illustrated in tab. ii. of Heim's 'Recherches' (*D. zeylanica*, Thw.). They may briefly be summed up as follows:—Branches of inflorescence glabrous, except in *D. congestiflora*, Thw. Calyx-segments glabrous, imbricate, the two outer and the third larger at time of flowering than the two inner, in some species all segments equal. Anther-cells equal; connective prolonged into a short obtuse clavate or spathulate appendage; style filiform, without stylopodium; fruit tightly enclosed by the enlarged basis of the fruiting-calyx segments, three of which grow out into obtuse wings. Cotyledons auriculate and lobed, flat but folded and twisted many times, the testa entering into the folds, filled with

mucilage, which swells in water, the whole forming a thick fleshy mass which encloses the lignified placenta. Cells filled with starch-grains of different sizes. The 5 abortive ovules at the top of the placenta. Hypocotyl short, lying between the folded auricles of the cotyledons. Gaertner's figure, Fruct. i. tab. 45, of *Caryolobis indica*, as already pointed out by Trimen, correctly represents the seed of *Doona*, only the folds of the cotyledons are not drawn. It would, however, be out of place to substitute *Caryolobis* for *Doona*, a name now well established. In the germinating seed the cotyledons are on short petioles; in some species the pericarp is thrown off, in others the cotyledons remain enclosed in the winged fruit. The first leaves above the cotyledons are always opposite.

The pith of a leaf-bearing internode has in its circumference 3–20 resin-ducts, generally unequal in diameter, the larger ones having three times the diameter of average pith-cells. (In the seed of *D. trapezifolia*, Thw., the pith of the hypocotyl has 8 resin-ducts in its circumference.) An apical and 2 lateral leaf-traces, the latter generally entering the bark a very short distance below the node, in some cases in the upper third of the internode. Each leaf-trace has 1, sometimes 2–3 ducts in the pith. Distinct stipular traces in the species with large stipules. In most species large mucilage-cavities in the pith as well as in the cortex. In the petiole a semicircle of 3–11 mostly confluent vascular bundles, each with one resin-duct. In the central mass of vascular bundles no ducts as a rule, in some instances one.

Endemic in Ceylon, 11 species (fully described in Trimen, Fl. Ceylon, i.), with 1 added (I think correctly) by Pierre.

1. D. ZEYLANICA, Thw. in Kew Journ. Bot. iv. (1852) 7; Trimen, Fl. Ceylon, i. 119.
2. D. AFFINIS, Thw. Enum. Pl. Zeyl. (1859) 35; Trimen, Fl. Ceylon, i. 120.
3. D. GARDNERI, Thw. Enum. Pl. Zeyl. (1859) 35; Trimen, Fl. Ceylon, i. 121.
4. D. NERVOSA, Thw. Enum. Pl. Zeyl. (1858) 35; Trimen, Fl. Ceylon, i. 121.
5. D. TRAPEZIFOLIA, Thw. Enum. Pl. Zeyl. (1858) 35; Trimen, Fl. Ceylon, i. 121.
6. D. CONGESTIFLORA, Thw. Enum. Pl. Zeyl. (1858) 35; Trimen, Fl. Ceylon, i. 122.

7. DOONA CORDIFOLIA, Thw. Enum. Pl. Zeyl. (1858) 35; Trimen, Fl. Ceylon, i. 122.
8. D. OVALIFOLIA, Thw. Enum. Pl. Zeyl. (1864) 402; Trimen, Fl. Ceylon, i. 123.
9. D. OBLONGA, Thw. in [London] Journ. Bot. xxiii. (1885) 206; Trimen, Fl. Ceylon, i. 123.
10. D. (?) VENULOSA, Thw. Enum. Pl. Zeyl. (1864) 402; Trimen, Fl. Ceylon, i. 123.
11. D. MACROPHYLLA, Thw. Enum. Pl. Zeyl. (1864) 402; Trimen, Fl. Ceylon, i. 124.
12. D. DISTICHA, Pierre, Fl. For. Cochinch. fasc. 15 (1890), t. 237 in obs.—*Vatica disticha*, A. DC. in DC. Prodr. xvi. (pars 2), 620; Dyer in Hook. f. Fl. Brit. Ind. i. 303.—*Sunaptea ? disticha*, Trimen, Cat. Ceylon Pl. (1885) 9, et Fl. Ceylon, i. 127.

The buds of *D. disticha* are so young in specimens at Kew and the British Museum, that a satisfactory examination is not possible. But the calyx is imbricate, and the appendix of the connective resembles that of *D. nervosa*, Thw., with which Pierre compares it. The bracts are hairy, but branches of inflorescence and calyx are perfectly glabrous. As regards the internal structure, it has numerous mucilage-cavities in the cortex, resembling those of *Doona*. Regarding internode and petiole, I must reserve my opinion until I have been able to make a more complete examination of this interesting species.

5. HOPEA, *Roxb.*

(Including *Petalandra*, Hasskarl, *Hancea*, Pierre.)

Stipules minute or small, early deciduous. Flowers almost always in unilateral spikes or racemes, these generally in racemose, rarely compound panicles. Calyx often glabrous, but petals always hairy outside. Calyx-segments imbricate, the two outer ones in the flower generally much larger than the others; growing into thin membranous wings, as the fruit ripens. Stamens 15, 10 in a few species; anther-cells equal; connective prolonged into a long awn. Stylopodium in most species large, in some (of section *Dryobalanoides* and *Petalandra*) wanting, but generally indicated by a ring of hairs.

The seed I have had an opportunity of examining in 15 of the 46 species. In 9 species I have found the structure which

may be regarded as normal for this genus. These species are:— Sect. *Euhopea*: *discolor*, *odorata*, *dealbata*. Sect. *Petalandra*: *fagifolia*, *Curtisii*, *Recopei*. Sect. *Dryobalanoides*: *intermedia*, *Pierrei*, *myrtifolia*. In this type the cotyledons are thick fleshy, the outer rounded surface longitudinally channelled; both bifid to the point of attachment of the hypocotyl. The outer or radicular cotyledon generally more or less concave, embracing the inner or placentar cotyledon. Hypocotyl and petioles of cotyledon half as long or as long as the seed, generally hairy, except the glabrous shining tip, imbedded on the outside of the embryo in a groove between the lobes of the outer cotyledon, while the lignified placenta with the remains of dissepiments intrudes between the lobes of the inner. From the type *Hopea globosa* differs by the position of the hypocotyl in the axis of the embryo between the inner edges of the 4 cotyledonary lobes. In *H. nervosa* the hypocotyl is short, not enveloped by the cotyledons, which are both directed towards the base of the seed, one being bifid, the other emarginate. In *H. ferrea* the hypocotyl is nearly as long as the cotyledons, which are both bifid, the two lobes of one being turned upwards, while the lobes of the other are directed towards the base of the fruit. These three species belong to the section *Euhopea*. In *Dryobalanoides* are three species with albuminous seeds when ripe, and thin foliaceous cotyledons, viz.: *H. Beccariana*, *Mengarawan*, and *cernua*. The albumen is gelatinous. The non-nitrogenous substances stored in the cotyledons of *Hopea* are starch and fat, the former generally prevailing.

It appears most convenient to adopt the old division into 3 sections:—(1) *Euhopea* and (2) *Petalandra*, with a limited number of prominent secondary nerves, the former with 15, the latter with 10 stamens; (3) *Dryobalanoides*, with numerous but not distinct secondary nerves and 15 stamens.

The anatomical structure of the different species of *Hopea* shows greater variety than is generally found in the genera of this family. It will be convenient, in the first instance, to describe the structure of *Hopea cernua*, T. et B. At the base of a leaf-bearing internode the pith has a triangular shape, two sides being straight and the third concave. Three large resin-ducts are always present, and they are located in the corners of the triangle. In most cases there is a fourth duct in the third concave side of the triangle. This fourth duct is intended for the apical leaf-trace

of the next higher internode. The case seems to be analogous to what has above been noticed in regard to *Dryobanalops aromatica* and *oblongifolia,* where the main resin-duct sometimes branches below the base of the internode. Of the 3 corner ducts one is destined for the apical, the other 2 send branches into the lateral leaf-traces of the internode. These 4 resin-ducts run through the pith in the same manner for more than half the internode, and Plate I. fig. 7 represents a section made at about $\frac{2}{3}$ of its length. Higher up (fig. 8) the 2 lateral ducts bifurcate, and the branches, which are intended for the lateral leaf-traces, pass through the wood into the bark, where we find them in a section made immediately under the petiole (fig. 9). At the same time the apical resin-duct has subdivided into 5 branch-ducts, the 2 lower and larger of which enter the axillary bud, while the 3 others enter the apical leaf-trace. Burck ('Sur les Diptérocarpées,' p. 161) states that the lateral cortical leaf-traces do not enter the petiole, but lose themselves in the intercellular spaces of the stipular cushion. In the case of *Hopea cernua*, I have not yet been able to make the examination necessary to verify this statement; but in the case of two nearly allied species, *H. Mengarawan*, Miq., and *H. Pierrei,* Hance, I am certain that the lateral leaf-traces enter the petiole. The stipules in these species are exceedingly small and early deciduous. The two species last mentioned have a structure similar to that of *H. cernua*, but there are important differences. *H. Pierrei* has 5, not 4, resin-ducts at the base of the internode, and *H. Mengarawan* has 8–10. They agree, however, with *H. cernua* in this point, that the apical duct subdivides into a large number, up to 8, some of which enter the petiole, while the others are destined for the axillary bud. They also agree in this point, that the two lateral leaf-traces do not run through the bark for any distance; they separate from the central cylinder immediately under the insertion of the petiole. Burck claims for *H. cernua* and the other species of section *Dryobalanoides* two main resin-ducts, which run through the entire axis and send out branches into the apical and lateral leaf-traces. Matters are apparently more complicated and more varied in the different species of this section.

The petiole of *Hopea cernua* has at its base 3 distinct vascular bundles, one on the underside, 2 lateral, each containing one resin-duct (Plate I. fig. 13). The central mass consists of a four-sided ring of xylem and phloëm, enclosing a semicircular

vascular bundle. At the top, below the blade, the 2 lateral ducts have bifurcated and the central mass has changed its shape (fig. 14). In the midrib near the base of leaf (fig. 15) the 3 vascular bundles have united and form a semicircle containing 5 resin-ducts, with a bend below, closed on the upperside by a belt of bast which forms a closed ring all round, and bands of xylem and phloëm. *Hopea Pierrei,* Hance, has a similar structure. *H. Mengarawan*, however, has at the base 5 resin-ducts in 3 distinct vascular bundles, and at the top of the petiole the central mass contains 3 resin-ducts.

The species belonging to the other two sections of the genus, *Petalandra* and *Euhopea,* have, so far as known, that in common with *H. cernua* and allied species, that the lateral leaf-traces have only a very short transit in the bark; they differ, however, in this, that the apical resin-duct divides itself into 2 branches only, one destined for the apical leaf-trace, the other for the axillary bud. As regards the number of resin-ducts at the base of the internode, *H. fagifolia,* Miq., *Recopei*, Pierre, *dealbata,* Hance, *oblongifolia,* Dyer, according to Pierre, *H. odorata,* Roxb., and *glabra,* W. et A., according to my observations, have from 8–12 resin-ducts in the pith at the base of the internode: *H. ferrea,* Pierre, however, has only 4. It should be added that the resin-ducts at the base of the internode in *H. cernua*, *Pierrei,* and *Mengarawan* are remarkable for their uniformly large diameter, as compared with the other species, in which the ducts are often very unequal in width.

As regards the petiole, fig. 16 gives that of *H. odorata* below the blade as an example. The main point is, that the outer semicircle consists of a somewhat larger number of vascular bundles and resin-ducts than in *Dryobalanoides*; they vary from 5 to 9, and in some species there is in addition a duct in the central mass.

Undoubtedly, as regards internode and petiole, the species of sections *Petalandra* and *Euhopea* are similar to many species of *Shorea* and, barring the mucilage-cavities, also to the species of *Doona.* This circumstance has induced Burck to limit the genus *Hopea* to the species which agree with *H. cernua* in structure, and to transfer all others to *Doona,* including *Hopea odorata,* the species upon which Roxburgh founded the genus. This change, however, cannot be maintained. Apart from the mucilage-ducts in pith and cortex, *Doona* has in the structure of flowers, fruit,

and seed a number of peculiar characters, separating it completely from the species of *Hopea* in question.

A different and more correct proceeding would be, to restrict the name *Hopea* to the species of Section *Euhopea*, and perhaps of *Petalandra* also. In that case *Dryobalanoides* would constitute a separate genus. Before this is done, however, the anatomical structure and the structure of the seed of a much larger number of species must be studied than is the case at present.

As at present constituted, 46 species of *Hopea* are known, which are distributed over the entire area occupied by the order, viz.: 3 species in Ceylon, 4 in the Western Peninsula of India, 13 in the Eastern Peninsula, 23 in Borneo, Sumatra, and the other islands of the Archipelago, 2 in the Philippine Islands, and 1 in New Guinea.

Sect. I. Euhopea.

Secondary nerves conspicuous, not approximate, not more than 20 pairs. Stamina 15, sometimes 12–15. Stylopodium always large.

A. *Ceylon.*

1. Hopea discolor, *Thw. Enum. Pl. Zeyl.* (1859) 36; *Trimen, Fl. Ceylon*, i. 125.—Pl. II. figs. 5, 6.

Leaves clothed beneath with a bright brown scurf consisting of very minute stellate hairs. Flowers pedicellate (calyx glabrous, 2 bracteoles at base of pedicels), in short axillary panicles consisting of few short unilateral racemes. The racemes (branches of panicle) often stand in the axil of 3 bracts, the 2 lateral being stipular (fig. 6). In fig. 6, 1—1 is the main axis of the panicle, while 2—2 is that of the raceme. Of the 2 bracteoles subtending the first fl. of this raceme, one only is visible. Ovary and short conical stylopodium hairy; style glabrous; stigma minute (fig. 5). Cotyledons fleshy, the cells filled with starch, both bifid, the outer concave, embracing the inner, which is smaller. Radicle half the length of the embryo, pubescent in its upper part, black shining at the end. Placenta and dissepiments intruding between the lobes of the inner, smaller cotyledon.

2. H. jucunda, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Trimen, Fl. Ceylon*, i. 125.

Secondary nerves 3–4 pairs, prominent, strongly curved, the 2 upper meeting at the apex; tertiary nerves distinct, parallel, at right angles to the midrib. Panicles racemose, often longer

than leaf, the branches at right angles to the rachis, regularly alternating and distichous, consisting of unilateral 3–4-flowered racemes. Fl. ⅓ in. long; calyx glabrous, segments acute, unequal. Ovary gradually narrowed into a conical stylopodium and long cylindrical style. Larger segments of fruiting-calyx oblanceolate, subfalcate, acute, 7–9-nerved.

Hopea modesta, A. DC., is classed as a small-leaved variety by Dyer and Trimen. I wish to draw attention to the following characters, which at first sight seem to justify its separation from *H. jucunda.* Panicles twice the length of leaf, rachis and branches filiform; branches forming an acute angle with rachis, each bearing 1–3 flowers which are less than half the size of *H. jucunda.* There is, however, a form of *H. jucunda* (C. P., 3710) which as regards size and nervation of leaves holds the middle between it and *H. modesta.* The fruit of *H. modesta* does not seem to be known. Until the trees have been thoroughly studied on the spot, and until fruit and seed of both have been compared, it is convenient to maintain the present arrangement.

3. HOPEA (?) CORDIFOLIA, *Trimen, Fl. Ceylon,* i. 126.

Leaves very similar to those of *Balanocarpus zeylanicus,* Trimen.

B. *Western Peninsula.*

4. H. PARVIFLORA, *Bedd. Forest Report,* 1863–4, cum tab., *et Fl. Sylv.* t. 7 (errore t. 6); *Dyer in Hook. f. Fl. Brit. Ind.* i. 308.—H. decandra, *Buchanan, MS.*—Pl. II. fig. 7.

Moist forests of the Western Ghats, from South Canara to Tinevelly. The "*Ironwood of Malabar,*" *Bovumara,* Canara, Buchanan; "*Nirkongu,*" Tinevelly, Beddome.

Flowers small, on very short pedicels, each subtended by 2 bractlets, in unilateral racemes, these distichous and regularly alternating. Calyx and branches of inflorescence grey, tomentose; the 2 outer sepals much larger than the others. Petals entirely glabrous, erose at apex. Anthers small, orbicular. Ovary, stylopodium, and style glabrous; stigma 3-fid (fig. 7). Stylopodium ovoid, constricted at base.

5. H. WIGHTIANA, *Wall. List* (1828), n. 6295; *Dyer in Hook. f. Fl. Brit. Ind.* i. 309; *Wight, Ill.* t. 37.

Moist forests at the foot of the Western Ghats, from North Canara to Quilon. Often gregarious, large tracts in the plains of South Canara stocked with it.

Flowers large, ⅓ in. long, shortly pedicellate, each in the axil of

2 bracteoles, which are often connate. Calyx perfectly glabrous; the 2 outer sepals larger, petals pubescent on the outside. The upper portion of ovary puberulous; stylopodium glabrous, slightly verrucose; style short. Round, echinate fruit-like excrescences (galls) in the axils of the leaves.

6. HOPEA GLABRA, *Wight et Arn. Prodr. Penins. Ind.* (1834) 85; *Dyer in Hook. f. Fl. Brit. Ind.* i. 309.—H. Wightiana, var. glabra, *Bedd. Fl. Sylv.* t. 96.

Forests of the Tinevelly Ghats; banks of Periyar river, Travancore, *Beddome.* Common on the banks of the Colatoor river, Travancore, *Bourdillon* n. 288.

A large tree, glabrous. Leaves lanceolate. Secondary nerves 7–9 pairs; tertiary numerous, mostly parallel, prominent. Flowers $\frac{1}{4}$ in. long; calyx glabrous. Petals slightly puberulous on the outside and ciliate on the edges. Ovary and stylopodium puberulous; style very short, glabrous. Fruit enveloped in the thinly membranous segments of fruiting-calyx, the larger of which are linear-oblong, $2\frac{1}{2}$ in. long, 7-nerved with prominent transverse veins. Specimens in fruit were received at Kew from Mr. Bourdillon.

7. H. RACOPHLŒA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 310.—H. malabarica, *Bedd. Ic. Pl. Ind. Or.* (1874) 42, t. 185.

Fl. large, $\frac{1}{3}$ in. long; calyx glabrous. Similar to *H. jucunda*, Thw., but decidedly different. Panicles clustered, 2–4 in one leaf-axil; calyx-lobes obtuse, equal. Stylopodium cylindrical, slightly narrowed at base, as long as ovary. Style very short. Larger segments of fruiting-calyx spathulate, obtuse, with 7–11 longitudinal nerves. The bark is blackish, peeling off in long recurved strips, which hang all round the trunk (*Beddome*).

H. racophlœa as well as *H. jucunda* have hairy glands (domatia) in the axils of the secondary nerves. In the case of *H. racophlœa* these glands are very large, with one or two round openings at the apex.

C. *Eastern Peninsula.*

1. *Leaves ovate or elliptic-ovate.*

8. H. ODORATA, *Roxb. Hort. Beng.* (1814) 42, *et Pl. Coromandel,* iii. (1819) 7, t. 210; *Dyer in Hook. f. Fl. Brit. Ind.* i. 308: *Pierre, Fl. For. Cochinch.* fasc. 16, t. 244.—H. Sangal, *Korth. Verh. Nat. Gesch. Bot.* (1839–42) 75, fide *Burck.*—Doona odorata, *Burck in Ann. Jard. Buitenz.* vi. (1887) 233.

Moist forests in the Southern portion of the Eastern Peninsula, from Pegu and Tenasserim to Cambodia and Cochinchina. Also in the Andamans. Not known with certainty north of 24° N. lat. Roxburgh, Fl. Ind. ii. 609, gives as its native place the mountains to the eastward of Bengal. Kurz, F. Flora B. Burma, i. 121, gives Chittagong. I have seen no specimens from so far north. *Hopea eglandulosa*, Roxb. l. c. 611, from the hills of Tipperah, is, according to Kurz, not a *Hopea* but a *Cyclostemon.* Borneo. Probably not in the Malay Peninsula. Evergreen, not gregarious, but scattered in the mixed forest.

Branches of inflorescence and calyx grey-tomentose. The two outer calyx-segments very slightly larger than the others. Petals pubescent outside, erose, ciliate at margins. Anthers oblong. Ovary gradually narrowed into a conical stylopodium and long cylindrical style. Ovary and stylopodium puberulous. Both cotyledons bifid to base, the outer concave, larger, embracing the inner, between the lobes of which the lignified placenta with the remains of the dissepiments intrudes, having at the apex the 5 abortive ovules. Hypocotyl with 2 hairy lines down to the tip, which is glabrous, brown, shining, together with the 2 short petioles nearly as long as seed, lying between the lobes of the outer cotyledon. Glands in the axils of the leaves (domatia) common; their absence, however, does not justify the establishment of variety *eglandulosa*, Pierre. *S. vasta*, Wall., with larger panicles, nearly as long as leaf, and larger segments of fruiting-calyx, may be accepted as a variety. *H. flavescens*, found in Cambodia by Dr. Harmand, and described by Pierre as a variety of *H. odorata*—with large compound, densely tomentose panicles, the branches of which sometimes stand in the axils of large lanceolate bracts—may possibly, when the fruit is known, turn out to be a distinct species.

Herbarium specimens of *H. odorata* and *H. parviflora* are exceedingly alike, but calyx, petals, anthers, and stylopodium different. There is a remarkable analogy with *Dipterocarpus turbinatus* and *indicus*. Two species which inhabit the moister regions of the Western Peninsula are closely allied to two species of the Eastern Peninsula of India.

9. H. MULTIFLORA, *Brandis.*—Doona multiflora, *Burck in Ann. Jard. Buitenz.* vi. (1887) 234.

Sumatra; Penang, Government Hill (*Curtis*).

Leaves glabrous, coriaceous, ovate-lanceolate, with long obtuse

acumen. Second. nerves slender, 7–9 pairs, gradually separating from midrib, then arching; tertiary distant, parallel. Fl. small, pedicellate, in unilateral racemes; calyx pubescent. Awn twice the length of anther; ovary and small stylopodium puberulous; style short, glabrous, obtuse.

10. Hopea globosa, sp. nova. Arbor magna, præter fructum glabra. Folia submembranacea, elliptica, acuminata. Fructus globosus (cum calyce) puberulus, calycis segmentis obtusis fere spathulatis multinerviis.

Perak (*L. Wray, Jr.*, n. 816), "*Damer Mata Kuchin.*"

Secondary nerves 8–10 pairs; tertiary mostly reticulate; blade 3–4, petiole $\frac{1}{4}$ in. long. Segments of fruiting-calyx slightly imbricate, not enclosing the fruit, the two outer 2–3 in. long, $\frac{3}{4}$ in. broad, with 12–14 longitud. nerves, the three others rounded. Cotyledons fleshy, bifid to base, nearly equal. Hypocotyl nearly as long as embryo, pubescent excepting the tip, imbedded between the 4 lobes of the cotyledons, the cells of which are filled with starch.

11. H. ferrea, *Lanessan, Pl. Utiles Col. Fr.* (1886) 300; *Pierre, Fl. For. Cochinch.* fasc. 16 (1890), t. 249.

Lower Cochinchina, where in one place it grows gregariously, covering an entire mountain-side.

A most remarkable species, the exact position of which cannot be determined until the flowers are known. Segments of fruiting-calyx almost valvate. Fruit cylindric, black, shining. Embryo cylindric, slender; hypocotyl 3-sided, thickened at the apex; the cotyledons fleshy, 3-sided, bifid to base, the two lobes of one turned upwards, enclosing the hypocotyl, those of the other turned towards the base of the fruit. My observations agree with Pierre's excellent description, except that the cotyledons are chiefly filled with starch ("contiennent beaucoup de matière grasse," *Pierre*).

2. *Leaves oblong.*

12. H. oblongifolia, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 309.—Pl. II. figs. 3, 4.

Mergui.

Secondary nerves 10 pairs, arching; tertiary parallel, very indistinct, between them a multitude of fine veins, closely reticulate. Sepals pubescent, ciliate on the edges and puberulous

inside; in flower the two outer larger. Ovary, stylopodium, and style glabrous; stylopodium cylindric (fig. 4); ovules with a long pointed beak (fig. 3).

13. Hopea dealbata, *Hance in* [*London*] *Journ. Bot.* xv. (1877) 329; *Pierre, Fl. For. Cochinch.* fasc. 16, t. 246.

Cochinchina.

Leaves silvery grey beneath. Secondary nerves straight, 14–16 pairs; tertiary nerves indistinct.

Structure of embryo like *H. odorata*, according to Pierre.

14. H. nervosa, *King in Journ. Asiat. Soc. Bengal.* lxii. pars 2 (1893), 124.

Penang.

Very short intermediate nerves between the 16 pairs of secondary nerves; tertiary nerves distant, parallel and reticulate. Fruit tightly enclosed by the thickened base of sepals; pericarp thick, woody at apex, splitting into 3 valves, each bearing in the middle the traces of a dissepiment. Embryo, as far as can be judged from seeds, apparently not fully mature, different from other species of *Hopea*. Hypocotyl free, short, not enveloped by cotyledons, these fleshy, but folded, erect, both directed towards the base of the seed, one bifid to base, the other emarginate. Cells chiefly filled with starch.

15. H. Helferi, *Brandis.*—Vatica Helferi, *Dyer in Hook. f. Fl. Brit. Ind.* i. 302.—Pl. II. figs. 1, 2.

Mergui, 60 miles inland (*Helfer*, n. 716).

Resembles *H. nervosa*, King, but differs in its tomentose branchlets, leaves with cordate unequal-sided base, no intermediate secondary nerves, and the tertiary nerves parallel and approximate. Flowers pedicelled, in terminal panicles. Sepals unequal in flower, the 2 outer longer. Anthers on long broad filaments; appendage of connective longer than twice the anther (fig. 1). Ovary with the short broad stylopodium and the short style glabrous (fig. 2). Fruit unknown.

Somewhat similar, but with tertiary nerves reticulate, are leaves collected by Sulpiz Kurz on South Andaman Island, and marked by him *Hopea suavis*, a name which is not found either in his Andaman Report 1870, nor in his contributions towards a knowledge of the Burmese Flora, Journ. Asiat. Soc. Bengal, xliii. pt. ii. 1874.

D. *Borneo and other Islands of Indian Archipelago.*

16. Hopea grisea, sp. nova. Præter inflorescentiam glabra, ramulis longitudinaliter rugosis. Folia ovata, acuminata, coriacea, nitida, margine revoluta, nervis secundariis utrinque 6–8 arcuatis conspicuis, nervis tertiariis parallelis. Inflorescentia griseo-pubescens. Stamina filamentis brevibus complanatis, appendice antheras bis superante. Pistillum ovario in receptaculo crasso obconico paullum immerso, stylopodio parvo glabro, stylo filiformi quam ovarium longiore.

Borneo (*Beccari*, nn. 2232, 2267).

Flower-buds just before opening $\frac{1}{4}$ in. long, panicles shorter than leaves; blade $2\frac{1}{2}$–3 in., petiole $\frac{1}{2}$ in. long. Fruit unknown.

17. H. Lowii, *Dyer, MS. in Herb. Kew.*

Borneo (*Lowe*); Sumatra (*Teysmann*).

Similar in appearance to the preceding, but the petioles are shorter and the ovary is quite different, with a very short, broad, obtuse, hairy stylopodium, and a short glabrous style. Specimens too imperfect for adequate description.

18. H. longiflora, sp. nova. Arbor glaberrima (nisi petala), ramis flexuosis lenticellatis. Folia crasse coriacea, e basi cordata lanceolato-falcata, nervis secundariis utrinque 10–12 arcuatis demum intramarginalibus, nervis tertiariis conspicuis parallelis et reticulatis. Flores breviter pedicellati. Calycis segmenta glabra, margine ciliata. Petala linearia, extus pilosa. Stamina connectivi appendice antheras æquante. Ovarium superum cum stylopodio elongato-conico styloque cylindrico, glaberrimum.

Borneo (*Haviland*, n. 2120; *Beccari*, n. 2811 (?)).

Blade 6–9 in. long, probably longer, petiole $\frac{3}{4}$ in. Fl. $\frac{1}{2}$ in. long. The 5 inner stamens on long, thick, cylindrical filaments. Anthers articulate with filaments, bend down, after the pollen has been shed. Fruit unknown.

19. H. Heimiana, *Brandis.*—Cotylelobium hopeifolium, *Heim in Bull. Soc. Linn. Paris*, i. (1891) 971.

Borneo (*Beccari*, n. 2491).

A most interesting species, of which, however, neither perfect flowers nor fruit are available. Between the 10 pairs secondary a few shorter intermediate nerves, tertiary reticulate. Fl. pedicellate in unilateral racemes, which are distichous and regularly

alternating, forming axillary panicles a little longer than leaf. Calyx-segments strongly imbricate, thickened at base, tightly enclosing the ovary after petals have fallen, the 2 outer a little larger. A few anthers were found, which were ovate, shorter than the dilated filaments. Ovary glabrous below, hairy in its upper part, terminating in a short conical stylopodium; ovules long, rostrate. Style short, cylindric, with 3-fid stigma.

Whatever revelations the discovery of flowers and fruit may bring, this species is not a *Cotylelobium*. Nervation of leaves, imbricate calyx, short anthers, and short style forbid this.

20. HOPEA CELEBICA, *Burck in Ann. Jard. Buitenzorg*, vi. (1887) 237.
Celebes.

21. H. CORIACEA, *Burck in Ann. Jard. Buitenzorg*, vi. (1887) 237.
Borneo.

22. H. DIVERSIFOLIA, *Miq. Fl. Ind. Bat. Suppl.* (1860) 491.
Sumatra.
Somewhat resembles 9. *H. multiflora*, but the leaves are puberulous beneath. Secondary nerves 10–12 pairs; tertiary numerous, approximate, parallel.

23. H. NIGRA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 238.
Borneo?

24. H. SERICEA, *Blume, Mus. Bot.* ii. (1852) 35; *Burck in Ann. Jard. Buitenz.* vi. (1887) 238.—[Not seen.]
Borneo.

E. *Philippines.*

25. H. PHILIPPINENSIS, *Dyer in* [*London*] *Journ. Bot.* xvi. (1878) 100.
(*Cuming*, n. 879; *Vidal*, n. 2164.)
Leaves thinly coriaceous, very unequal-sided at base. Larger segments of fruiting-calyx spathulate, obtuse, with 6–8 very prominent longitudinal nerves.

26. H. PLAGATA, *Vidal, Sinopsis, Atlas* (1883) t. 15 A. figg. 1–4, *et Pl. Vasc. Filip.* (1886) 62.—Mocanera plagata, *Blanco, Fl. Filip.* ed. I. (1837) 447.—Dipterocarpus plagatus, *Blanco, Fl. Filip.* ed. II. (1845) 311.
Bongabon, prov. Nueva Ecija, Luzon (*Vidal*, n. 84).

Apparently anomalous. Blanco states stamens more than 30, and no style, and this seems to agree with Vidal's figure. The fruiting-calyx, however, is said to have 2 wings. Vidal's n. 84 (leaf only) has thinly coriaceous lanceolate leaves, perfectly glabrous. Sec. nerves 8 pairs, arcuate; tertiary indistinct. Domatia on the underside in the axils of second. nerves.

F. *New Guinea.*

27. HOPEÆ sp., *Dyer in* [*London*] *Journ. Bot.* xvi. (1878) 100. —[Not seen.]

Mt. Arfak (*Beccari*).

Sect. II. PETALANDRA, *Hassk.* (genus).

Secondary nerves conspicuous, not approximate, not more than 20 pairs; tertiary nerves generally parallel, approximate, but not conspicuous. Stamens 10, on broad short filaments, which are sometimens monadelphous. Stylopodium either wanting, or a fleshy rim or tube on the top of the truncated ovary.

28. H. FAGIFOLIA, *Miq. Fl. Ind. Bat. Suppl.* (1860) 490.—Petalandra micrantha, *Miq. Fl. Ind. Bat.* i. (pars 1) 505—Doona micrantha, *Burck in Ann. Jard. Buitenz.* vi. (1887) 234.

Java; Bangka; Sumatra.

Tertiary nerves faintly visible on both sides of leaf. Flowers on pedicels nearly as long as calyx, in unilateral racemes, these in racemose panicles. Ovary glabrous; no stylopodium; style short. Fruit loosely enveloped by the base of calyx-segments. Embryo channelled outside. Hypocotyl nearly as long as embryo. Cotyledons bifid, the outer concave, embracing the inner.

29. H. JAVANICA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 235, t. 29. fig. 7.

Java.

Tertiary nerves numerous, parallel, the reticulate veins connecting them more distinct than in *H. fagifolia.*

30. H. CURTISII, *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 124.

Perak.

Tertiary nerves numerous, parallel, obscure. Flowers on very short pedicels in unilateral racemes. Stamens 10 (*King*), on broad, very short filaments; awn longer than anther. Ovary cylindric, glabrous; rim of truncate apex hairy, slightly raised and

lobed. Style short, glabrous; stigma minute. Pericarp thin, chartaceous. Both cotyledons thick, fleshy, bifid to base. Hypocotyl as long as embryo, above the tip with a few hairs, lying on the outside of the embryo between the lobes of the radicular cotyledon, which is slightly concave, somewhat embracing the other, smaller cotyledon, between the lobes of which the placenta and remains of dissepiments are intruded. Cells of cotyledons filled with starch and a little fat.

31. HOPEA RECOPEI, *Lanessan, Pl. Utiles Col. Fr.* (1886) 301; *Pierre, Fl. For. Cochinch.* fasc. 16 (1891), t. 247.

Province of Bienhoa in Cochinchina, where it grows gregarious, covering entire mountain-sides.

Tertiary nerves parallel but distant, joined by closely reticulate veins. 10 monadelphous stamens; anthers without appendage. Upper rim of ovary continued into fleshy cylindric stylopodium, which encloses the short style. Structure of embryo like that of *H. Curtisii.* Cells of cotyledons filled with starch.

Sect. III. DRYOBALANOIDES.

Secondary nerves numerous, approximate, not prominent, and often obscure. Stamens 15. Stylopodium in some species wanting, indicated by a hairy ring.

The species of this section resemble each other much in habit. The flowers are always in unilateral racemes, which are arranged in racemose, rarely compound panicles; the fruit is always in its lower portion, and sometimes the entire fruit, tightly enclosed by the indurated and thickened base of calyx-segments. The existence or not of a stylopodium furnishes an excellent character. King speaks of an hourglass-shaped ovary. The ovary-cells, however, only occupy the lower half of the hourglass (Plate II. fig. 10), the upper portion being a fleshy stylopodium. Where the stylopodium is small or wanting, as in *Hopea Mengarawan* and allied species, its place is indicated by a hairy ring at base of style. In some species the existence of a stylopodium can be recognized in fruiting specimens (*H. Beccariana*, Burck; *H. Dyeri*, Heim; *H. Treubii*, "plate-forme circulaire, munie d'un apicule," Heim). Of the 15 species of this section, I am disposed to think that *H. intermedia*, King, *H. borneensis*, Heim, *H. sarawakensis*, Heim, and perhaps also *H. Vesquei*, Heim, will disappear as more abundant material for examination becomes available.

1. *Stylopodium distinct; flowers nodding.*

32. HOPEA PIERREI, *Hance in* [*London*] *Journ. Bot.* xv. (1877) 329.—H. micrantha, *Hance in* [*London*] *Journ. Bot.* xv. (1876) 242; *non Hook. f.*—Hancea Pierrei, *Pierre, Fl. For. Cochinch.* fasc. 16 (1891), t. 248 (in tabulâ autem *Hopea Pierrei*).—Pl. II. fig. 10.

Singapore (*Ridley*); Cambodia, on the hills of Camchay and the island Phu Quoc; Borneo (*Beccari*, nn. 2504, 3050).

Glabrous, only petioles and ramifications of inflorescence slightly puberulous; small hairy glands (domatia) occasionally in the axils of secondary nerves. Flowers drooping, pedicellate, in unilateral racemes, these distichous and regularly alternating, forming short axillary racemose panicles. Bracteoles ciliate. Calyx glabrous; petals sericeous outside; awn of connective longer than twice the anther. Stylopodium glabrous as well as ovary, constricted below; style very short; stigma obtuse. Fruit ovoid, slightly acuminate, very tightly enclosed by the 5, at base, indurated calyx-segments. Both cotyledons bifid to base, the radicular somewhat larger; hypocotyl half the length of embryo. Cotyledons filled with starch.

Pierre states that the tree attains 30 metres, and sends down into the ground aerial roots from the branches like *Rhizophora*, *Ficus bengalensis*, *Ficus elastica*, and other species of *Ficus*, which support the tree after the original trunk has decayed. This is most remarkable. The leaves of *Ficus Benjamina*, Linn. (narrow-leaved form), are similar to *H. Pierrei*, but it is not likely that a mistake has been made.

33. H. INTERMEDIA, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 126.

Penang (*Curtis*, nn. 425, 1397, 1398); Perak (*Dr. King's* collector, n. 3709).

Glabrous, inflorescence occasionally puberulous. Leaves unequal-sided at base. Main secondary nerves 8–12 pairs, arching, numerous shorter intermediate nerves between, joined by very finely and closely reticulate veins. Flowers nodding, on pedicels half the length of calyx; 2–4 racemose panicles in the axil of one leaf. Calyx glabrous. Petals falcate, silky outside. Stamens 15, filaments dilated at base; the awn of the connective longer than anther and filament. Stylopodium constricted at base,

sometimes very slightly puberulous; ovary and the very short style glabrous. Ripe fruit glabrous, acuminate, in the Penang specimens nearly $\frac{1}{3}$ in. long, upper part free. Base of segments of fruiting-calyx not so much thickened as in *Hopea Pierrei.* Hypocotyl two-thirds the length of embryo, upper portion pubescent, tip black, glabrous. Cotyledons bifid to base, slightly unequal, the radicular cotyledon slightly concave. Cells filled with starch.

The differences between this and *Hopea Pierrei* are so slight that further researches on the spot may possibly establish the identity of the two. The above description has been drawn up from specimens in flower at Mus. Brit., in fruit at Kew.

King urges the relationship of *H. intermedia* with *H. Mengarawan* and *H. micrantha.* But these two have an altogether different ovary, narrowing into the style, without a distinct stylopodium.

34. HOPEA BECCARIANA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 240.—H. Nicholsoni, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 973.

Borneo (*Beccari,* nn. 1177, 2761).

Fruit acuminate, nearly $\frac{1}{4}$ in. long, crowned by the indurated bell-shaped stylopodium and style, which Heim correctly notices: "surmontés d'un léger renflement." Cotyledons foliaceous, but possibly the seed examined was not quite ripe.

35. H. VESQUEI, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 971.

Borneo (*Beccari,* n. 2550; *Haviland,* n. 857).

Structure of flower same as preceding, differs by smaller leaves and young shoots pubescent. Fruit not known.

36. H. TREUBII, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 955.

Borneo (*Beccari,* n. 2895).

Flowers not known. Leaves larger than those of the two preceding species, with long petioles. Fruit elongate conical, $\frac{1}{4}$ in. long, surmounted by the indurated broad stylopodium; "terminé par une petite plate-forme circulaire" (*Heim*).

37. H. DYERI, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 972. —H. microptera, *Dyer, MSS. in Herb. Kew.*

Borneo (*Beccari,* n. 2962).

Coriaceous, lanceolate, long acuminate leaves and very small fruit, barely $\frac{1}{6}$ in. long, surmounted by the indurated stylopodium similar to *Hopea Beccariana*; the wings $\frac{3}{4}$ in. long; flower unknown.

38. Hopea borneensis, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 972.

In bud and flower only. Heim says here and under *H. sarawakensis*, p. 971, that the inner sepals are larger, more developed. This I have not been able to verify: the outer sepals are triangular, longer, and much thicker at base than the inner (elliptic-concave) sepals.

2. *Stylopodium distinct; flowers erect.*

39. H. Griffithii, *Kurz in Journ. Asiat. Soc. Bengal*, xlii. pars 2 (1873), 60, *et For. Fl. Brit. Burma*, i. 122; *Dyer in Hook. f. Fl. Brit. Ind.* i. 310.

Mergui (*Griffith*); Singapore (*Ridley*).

14–24 pairs of main secondary nerves, with numerous intermediate nerves, which are shorter, joined by a system of very closely reticulate veins. Flowers sessile or shortly pedicellate, erect, in unilateral racemes, these in racemose axillary panicles, which are glabrous and much shorter than leaf. Stylopodium broad, constricted at base, shorter than ovary, glabrous; style short; stigma obtuse. Fruit unknown.

Var. pedicellata.—Penang (*Curtis*, 167); Sumatra (*Forbes*, 3205, 3208). Pedicels nearly as long as calyx. Branches of inflorescence puberulous in the Sumatra specimens.

40. H. sarawakensis, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 971.

Borneo (*Beccari*, n. 2987).

Placed here on account of the similarity of its leaf to that of *H. Griffithii*. Heim thinks it closely allied to *H. borneensis*.

41. H. dryobalanoides, *Miq. Fl. Ind. Bat., Suppl.* (1860) 492; *Burck in Ann. Jard. Buitenz.* vi. (1887) 241.

Sumatra, prov. Priaman (*Teysmann*).

Leaves only known; they resemble those of *H. Griffithii*.

3. *No distinct stylopodium, but base of style generally with a hairy ring; flowers nodding.*

42. Hopea micrantha, *Hook. f. in Trans. Linn. Soc.* xxiii. (1862) 161; *Dyer in Hook. f. Fl. Brit. Ind.* i. 310; *Burck in Ann. Jard. Buitenz.* vi. (1877) 239; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 124, partim.

Borneo (*Motley*, n. 215; *Barber*, n. 100); Malacca (*Maingay*, n. 210); Singapore (*Cautley*, n. 12).

Young shoots, inflorescence, petioles, and midrib pubescent. Leaves lanceolate, long-acuminate; blade 2–3 in. long, petiole $\frac{1}{3}$ in. long. Flowers $\frac{1}{12}$–$\frac{1}{10}$ in. long, often in compound racemes. Stamens 15, the connective terminating in a long awn. Ovary glabrous, suddenly narrowed into filiform style, which is as long as ovary. Hairy ring at base of style; stigma slightly 3-dentate.

King states, "ovary often constricted in the middle"; this remark must refer to specimens of another species. He quotes Curtis's no. 167 under *H. micrantha*. This, however, is *H. Griffithii* var. *pedicellata*, which has the stylopodium constricted above the ovary. King gives 12 stamens; I always have found 15. Perak, Dr. King's collector n. 8170, I refer to *H. Mengarawan*.

43. H. Mengarawan, *Miq. Fl. Ind. Bat., Suppl.* (1860) 492; *Burck in Ann. Jard. Buitenz.* vi. (1887) 240.

Perak (*Dr. King's* collector, n. 8170, *Hopea micrantha*, King, not Hook. f.); Singapore (*Cautley*, n. 205; *Ridley*, nn. 5094, 5843, "*Merawan*"); State of Malacca (n. 1447); Sumatra (*Forbes*, n. 3210, *Teysmann*).

Perfectly glabrous, only branches of inflorescence slightly puberulous and outside of petals tomentose. Leaves broadly ovate, sometimes ovate-lanceolate; blade $2\frac{1}{2}$–3 in. long, up to 2 in. broad. Ovary like *H. micrantha*. Fruit $\frac{1}{4}$ in. long, lower part tightly enclosed in the enlarged, hard, and thickened base of calyx-segments; upper part free, conical, glabrous, shining, often terminated by the indurated style. Pericarp hard, crustaceous, splitting into 3–6 segments. Hypocotyl half the length of embryo. Cotyledons thin, fleshy, unequal, the larger 2-lobed to point of attachment, somewhat concave, enclosing the smaller, which is bifid.

44. HOPEA CERNUA, *Teysm. et Binn. in Nat. Tijdschr. Nederl. Ind.* xxix. (1867) 252.—Pl. II. figs. 8, 9.

Sumatra; Borneo (*Beccari*, nn. 2484, 2545, 2985).

Perfectly glabrous, only petals hairy outside. Leaves thickly coriaceous, elliptic or elliptic-lanceolate, blade 4–6 in. long, margins revolute; midrib on both faces very prominent. Main secondary nerves 16–24 pairs, arching, prominent, alternating with a large number of intermediate nerves, which are shorter and do not reach the edge of leaf. Flowers larger than in the allied species, up to $\frac{1}{6}$ in. long. Axillary panicles sometimes compound, always shorter than leaf. Fruit $\frac{1}{4}$ in. long, tightly enclosed by the thickened base of calyx-segments; pericarp thin, crustaceous. Albumen in the ripe seed; embryo small; cotyledons foliaceous, equal, nearly orbicular; radicle free, short, thick, obtuse.

Burck, *l. c.* 241, regards this as a large-leaved variety of *H. Mengarawan*, Miq.

4. *Species imperfectly known, but which probably belong to this section.*

45. H. MICROCARPA, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 954.—[Not seen.]

Borneo (*Beccari*, n. 2989).

46. H. MYRTIFOLIA, *Miq. Fl. Ind. Bat., Suppl.* (1860) 493; *Burck in Ann. Jard. Buitenz.* vi. (1887) 242.

Sumatra (*Teysmann*, leaves); Borneo (*Beccari*, n. 3021, leaves and fruit).

Branchlets, petioles, and midrib pubescent. Leaves chartaceous, from a rounded base ovate-lanceolate, shortly acuminate; principal secondary nerves 12–16 pairs, and between these numerous shorter intermediate nerves. Cortical leaf-traces apparently short. Fruit large, nearly globose, $\frac{1}{3}$ in. diam. Lobes of fruiting-calyx short, rounded, thickened and indurated. Pericarp thin, crustaceous, splitting up into 3–6 segments. Hypocotyl nearly as long as embryo, imbedded in a groove between the two lobes of the outer cotyledon; this is a little larger than the inner, which is also bifid to base and encloses lignified placenta with the remains of dissepiments. Cotyledons fleshy, filled with starch.

6. Pentacme, *A. DC.*

Sepals strongly imbricate. Petals broad, spreading. Stamens 15. Anthers oblong, on short broad filaments. Anther-cells equal, each prolonged into a short appendix; the connective also prolonged, so that each anther has 5 apical appendages. Ovary glabrous, prolonged into a conical stylopodium; style filiform, glabrous. Stigma obtuse, indistinctly 3-partite. The three outer segments of fruiting-calyx much larger than the others, narrowed into a stalk, but expanding into a broad base, which is adpressed to the lower portion of the fruit, but does not enclose it.

The anatomical structure is only known of *P. suavis*, A. DC. In the pith of the leaf-bearing internode 12–25 ducts, 3 leaf-traces, each with one duct, the two lateral enter the bark immediately under the base of petiole. Judging from the appearance of herbarium specimens, the cortical leaf-traces would seem to be as long as the internode in *P. paucinervis*. In the petiole a semicircle of 7–9 vascular bundles, each with one duct, 3 resin-ducts in the central mass.

Three species only known at present, two from the Eastern Peninsula and one from the Philippine Islands.

1. P. suavis, *A. DC. in DC. Prodr.* xvi. pars 2 (1864), 626.—P. siamensis, *Kurz in Journ. Asiat. Soc. Bengal,* xxxix. pars 2 (1870), 66; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), tt. 225–227; *Engler, Nat. Pflanzenfam.* iii. 6. fig. 122 A–C.—Shorea siamensis, *Miq. Ann. Mus. Lugd.-Bat.* i. (1863–4) 214; *Dyer in Hook. f. Fl. Brit. Ind.* i. 304.

A large tree, on dry ridges a shrub, bearing flower and seed. Leafless during part of the hot season. Throughout the Eastern Peninsula, north to the 25° N. lat., in Burma, Siam, and Cochinchina. In Pegu and Martaban scattered in the woods of *Dipterocarpus tuberculatus,* in Upper Burma and in Cochinchina gregarious.

Flowers showy, on pedicels as long as calyx, coming out in large panicles when the tree is leafless. Petals orbicular or broadly ovate, yellow, at flowering-time forming a hollow globe, open at the top only and enclosing stamens and ovary. Cotyledons thick, fleshy; the radicular concave, enclosing the other, both with large basal lobes; petioles well developed in the seed; radicle short plumula conspicuous. Cells filled with fat-oil.

2. Pentacme malayana, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 107.

Langkani, Malayan Peninsula.

Stipules linear; petals elliptic, three times as long as calyx (*King*).

3. P. paucinervis, sp. nova. Arbor præter inflorescentiam glabra. Folia crasse coriacea, ovata, nervis secundariis utrinque 6 arcuatis, cum costa inferne valde prominentibus. Flores paniculati, pedicellis brevibus. Petala obovata, emarginata. Stamina antheris apice 5-mucronatis. Pistillum ovario glabro, stylopodio elongato piloso, stylo longe exserto filiformi, stigmate obtuso.

Luzon; Philippines (*Shorea* sp.; *Vidal*, nn. 79, 1166, 2167).

Stipules minute, early caducous. Leaves from a rounded or subcordate base; midrib and 6 pairs of arching secondary nerves conspicuous; tertiary nerves mostly reticulate. Blade 4–6, petiole 1 in. long. Flowers nearly half inch long, on short obconical pedicels, in terminal and axillary panicles, the ramifications of which, as well as the outside of sepals and petals, are grey with dense stellate tomentum. Inside of sepals puberulous. Petals spreading. Valves of anthers nearly equal, terminating, as well as connective, in 5 nearly equal acute appendages. Style glabrous, thickened above; stigma obtuse. Fruit unknown.

7. Shorea, *Roxb. in Gaertn. f. Carpologia*, iii. 47; *Engler, Nat. Pflanzenfam.* iii. 6. figs. 123, 124.
(Including *Parahopea*, Heim.)

Large resinous trees; stipules in a few species large and persistent, in most small and early deciduous. Leaves coriaceous; secondary nerves prominent; tertiary nerves mostly parallel. Flowers as a rule in unilateral spikes or racemes, these distichous and regularly alternating on the branches of large axillary and terminal panicles. Each flower subtended by two mostly deciduous, in a few species persistent and conspicuous bracts. Sepals strongly imbricate, always hairy outside, and often inside also, on the margin of a broad obconical receptacle. Petals oblong, rarely ovate-oblong, hairy on the outside. Stamens generally 15, in some species more. Anther-cells generally equal; connective prolonged into a pointed appendage, generally longer than anther, sometimes short or wanting. Segments of fruiting-calyx with their broad bases tightly enclosing the fruit, the three outer ones

generally longer than the others and much longer than the fruit. In one section the segments of fruiting-calyx shorter or not much longer than the fruit.

The ripe seed generally without albumen. The cotyledons thick, fleshy, generally both bifid to their base, that is to the point where they are attached to the apex of the hypocotyl (radicle) or to the petioles, which in some species are well developed in the seed (*S. robusta*, *obtusa*). Sometimes (*S. brachyptera*) one cotyledon only is bifid, the other being emarginate. Two types may be distinguished, which are, however, connected by intermediate forms. In the seeds of the first type the lobes of the cotyledons are three-sided, prismatic, the two inner faces flat, the third outer face rounded, and in that case the hypocotyl is imbedded in a groove between the inner edges of the four cotyledonary lobes. In the second type one of the cotyledons is concave and embraces the other. In this case the hypocotyl (radicle) and petioles, if developed in the seed, are imbedded in a groove between the two lobes of the outer (radicular) cotyledon. In some cases the outer, in others the inner cotyledon is larger. The embryo of the first type is found in *S. stenoptera*, *aptera*, and *brachyptera*, all of section *Brachyptera*, in *Faguetiana* of *Pinanga*, and in *leprosula* and *Curtisii* of *Mutica*. The second type is represented by *S. robusta* and *obtusa* of *Eushorea*, by *Pinanga* and *macroptera* (sect. *Pinanga*), and by *glauca* of section *Mutica*. The cells of the cotyledons are mainly filled with starch in *S. robusta* and *obtusa* of sect. *Eushorea*, and in *S. Curtisii* of sect. *Mutica*, with fat-oil in *S. stenoptera*, *aptera*, and *scaberrima* of sect. *Brachyptera* and in *S. Pinanya* and *Gysbertsiana* of sect. *Pinanga*, while *S. glauca* and *leprosula* of sect. *Mutica* and *mamacroptera* of sect. *Pinanga* contain both starch and oil. The placenta is lignified and to it are attached the membranous remains of the dissepiments, and these intrude between the lobes of the inner (placentary) cotyledon.

The base of a leaf-bearing internode has from 3 to 30 resin-ducts in the circumference of the pith. In some species of section *Anthoshorea* these ducts are exceedingly small, not larger than the cells of the pith; ordinarily, however, their diameter is 3 to 5 times that of the ordinary pith-cells. As a rule there are 3 leaf-traces, two lateral and one apical, each with a resin-duct; the apical trace sometimes with several ducts. The two lateral traces separate from the central cylinder and enter the bark at

different levels. In *Shorea obtusa*, for instance, they run in the bark through the upper half of the internode, while in *S. robusta* they do not enter the bark until close under the insertion of the petiole. This, however, possibly varies in the same species. Pierre states (under *Pentacme siamensis*, plates 225–227) that the cortical leaf-traces in *Shorea robusta* run through two-thirds of an internode. I have always found them exceedingly short in this species.

Burck (*l. c.* p. 168) states that in *S. scaberrima, aptera* of section *Brachyptera*, and in *S. Pinanga* of section *Pinanga*, the lateral leaf-traces run through the bark for more than one internode and a half. For these three species and for *S. leprosula*, Miq. (*S. Maranti*, Burck), and *inappendiculata*, Burck, of section *Mutica*, the same author (*l. c.* p. 171) claims four lateral cortical leaf-traces instead of two. Of these four traces, which are found in the bark in the upper half of the internode, two, according to Burck, enter the petiole at the top of it, while the two others, after having run through the bark for an internode and a half, enter the petiole at the top of the next higher internode.

In those species which have large stipules there are lateral stipular, besides the leaf-traces. These stipular traces either branch off from the central cylinder, as is the case in *Dipterocarpus*, or they are branches of the lateral leaf-traces. Burck has justly said:—"Rien n'est plus inconstant, que le nombre de canaux dans la tige des *Shorea*." At the base of the leaf-bearing internodes of *S. robusta*, for instance, I have found this number vary from 3 to 20.

The petiole below the insertion of the blade as a rule has an open semicircle of 7 or 9 halfmoon-shaped vascular bundles, either distinct or connected each with a resin-duct. In some species, however (*S. obtusa*), there is a closed ring of vascular bundles. The central mass of vascular bundles consists of one or several curved bands, generally without, in some cases with 1–3 resin-ducts. *S. obtusa*, however, makes an exception. There are in the petiole of this species 10–12 ducts in the outer ring, and the same number in the central mass.

So far as known, all species of *Shorea* have horseshoe-shaped sclerotic cells in the cortex. Some species (*S. Talura*) have in pith and cortex cavities filled with gum, similar to those in *Doona*.

This, the largest genus of the order, at present comprises 89

species, and extends from Ceylon and the Western Peninsula to New Guinea. Its greatest development *Shorea* has attained in the Eastern Peninsula of India with 37, in Borneo and the neighbouring islands of the Indian Archipelago with 35 species. As a rule the species inhabit a comparatively circumscribed area; among those of wider distribution may be mentioned the following:—

Shorea Balangeran, Burck: Bangka, Borneo, Philippine Islands.
S. squamata, Benth. et Hook.: Borneo, Philippine Islands.
S. furfuracea, Miq.: Malay Peninsula, Sumatra, Bangka and other islands, Philippine Islands.

Besides the small genera *Pentacme*, *Parashorea*, and *Isoptera*, *Balanocarpus* is closely allied to *Shorea*. Several characters, upon which we rely most in the classification of this order, are subject to great variation in this genus. I refer to the number of stamens, the shape of the anthers, the appendage of the connective, the style and stylopodium, and the conformation of the fruiting-calyx. Nevertheless the genus is well defined, and though it might be possible to establish some of the sections as distinct genera, it is more convenient at present to maintain *Shorea* undivided. These views may, however, become modified as new species are discovered, and as the anatomical structure and the structure of the seed of a larger number of species are studied.

Sect. I. Brachyptera, *Heim, Recherches*, p. 46.

Spikes or racemes, generally not distinctly unilateral. Segments of fruiting-calyx shorter than twice the length of fruit. Stamens generally 15; appendage of connective in most species long, filiform. Stigma minute. As far as can be seen on the outside of herbarium specimens, and without actual anatomical examination, the cortical leaf-traces run through the entire length of the internode.

1. Shorea lissophylla, *Thw. Enum. Pl. Zeyl.* (1864) 402; *Trimen, Fl. Ceylon*, iii. 117.

Rare in the moist low country of the southern division of Ceylon.

Stamens 30–40; anthers elliptic, cells unequal, the outer larger cells pointed at base; appendix of connective short, with a number of long ciliæ; anthers also ciliate at apex; filaments long, broad.

Ovary with a long bell-shaped fleshy stylopodium, both slightly puberulous; style short. These characters would place this species under *Eushorea*. But A. L. Broun, the Conservator of Forests in Ceylon, has sent me a sketch of the fruit, with short wings, which places it under section *Brachyptera*. It is, however, an anomalous species of this section.

2. SHOREA THISELTONI, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 122.—Pl. II. figs. 13, 14.

Perak; common.

Leaves coriaceous, glabrous, elliptic-oblong; upperside, when dry, of a dull grey, underside of a copper-colour. Anthers nearly orbicular, on long much dilated filaments, the 5 inner longer than the 10 outer. Connective thick, continued into a short acute appendix, that of the 5 inner stamens very short or wanting. Ovary narrowed into short hairy stylopodium; base of ovary and filiform style glabrous.

S. Forbesii, King, MSS., Sumatra (*Forbes*, 2815, 2952), has the same structure of flowers, the only difference being that the bracts seem to remain a little longer. I regard it as a variety of *S. Thiseltoni*.

The remaining 5 species of this section are all natives of Borneo; they have all 15 stamens, with a long filiform appendage of connective.

3. S. BRACHYPTERA, *Heim in Bull. Soc. Linn. Paris*, ii. (1891 957.—Pachychlamys Beccarianus, *Dyer*, *MSS.*

Borneo (*Beccari*, 2681, 3075, 3507).

Stamens 15, adhering to the base of the petals; 5 of the inner circle on longer filaments than the 10 outer ones, 5 of which are, as usual, opposite to the 5 inner stamens. Heim states: *étamines* 15 (5 *episépales*, 10 *epipétales*). This would make the pairs of stamens (one inner and one outer) epipetal, which is the opposite of what is found in all species of this order with 15 stamens. The materials at my disposal have not enabled me to settle this question. Ovary hairy, narrowed into glabrous filiform style; stylopodium not conspicuous. Of the two cotyledons the anterior only bifid, the posterior emarginate (*Heim*). Fruit ovoid, velvety, 1 in. diam.

4. SHOREA STENOPTERA, *Burck, Minjak Tangkawang,* (1886) p. 11, *et in Ann. Jard. Buitenz.* vi. (1887) 209, t. 21.

Borneo.

Stipules large, semiamplexicaul, caducous. Ovary glabrous; style as long as ovary, thickened at apex. Stylopodium not conspicuous. Fruit nearly 3 inches long, velutinous. Cotyledons fleshy, nearly equal, each bifid to the base, that is to the point where the hypocotyl is attached. Hypocotyl in the vertical axis of embryo, two-thirds the length of embryo.

5. S. APTERA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 210, t. 22.

Borneo.

Stipules small, caducous. Flowers in unilateral spikes. Ovary narrowed into short stylopodium, both hairy; style filiform. Fruit 1½ in. long. Structure of embryo same as in *S. stenoptera*; petioles of cotyledons distinct; these with hypocotyl nearly as long as seed.

6. S. MARTINIANA, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxii. (1871) 408; *Burck in Ann. Jard. Buitenz.* vi. (1887) 208, t. 29. fig. 2.

Borneo.

Stipules large, persistent, leaving annular scars, from a cordate base triangular, obtuse.

7. S. SCABERRIMA, *Burck, Minjak Tengk.* (1886) 22, *et in Ann. Jard. Buitenz.* vi. (1887) 208.—[Not seen.]

Borneo.

The seeds of the last four species as well as of *S. Pinanga*, Scheff., and *Gysbertsiana*, Burck, both of section *Pinanga*, and of *Isoptera borneensis*, Scheff., yield the Tangkawang fat. Besides these trees of the Dipterocarp family, *Diploknema sebifera*, Pierre, and perhaps other Sapotaceous trees in Borneo, yield fat, which is exported under the name of Minjak Tangkawang (Burck on Minjak Tangkawang, communicated in Pharmaceut. Soc. Journal, 1887, p. 901). In other species of *Shorea* (*S. robusta, obtusa*) the cells of the cotyledons are filled with starch. It is for further research, whether in the seeds of all species of this section and of the section *Pinanga*, fat-oil is the predominant non-nitrogenous stored substance.

Sect. II. Eushorea.

Fruiting-calyx with 3 long wings; stamens 20–60; appendage of connective ciliate, rarely not ciliate and then thickened at base. Stylopodium large, hairy as well as ovary; style short, glabrous; stigma minute. Flowers nearly in all species in unilateral spikes or racemes, these distichous and regularly alternating. Cortical leaf-traces in many, but not in all, species shorter than internodium.

A. *Ceylon.*

8. Shorea oblongifolia, *Thw. Enum. Pl. Zeyl.* (1859) 36; *Trimen, Fl. Ceylon*, i. 116.

Spikes unilateral, distichous; appendage of connective short, with 3 long bristles. Stylopodium as large as ovary, both densely tomentose.

9. S. Dyerii, *Thw. ex Trimen in* [*London*] *Journ. Bot.* xxiii. (1885) 204; *Trimen, Fl. Ceylon*, i. 117.

Spikes unilateral, distichous; appendage of connective half the length of anther, or shorter, strongly ciliated; apex of anther also ciliated.

The following two species, of which the flowers are unknown, either belong to this section or to *Anthoshorea.* The fruiting-calyx has 3 long wings; and neither *Pinanga* nor *Mutica* extend so far westward.

10. S. reticulata, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 307; *Trimen, Fl. Ceylon*, i. 117; *Thw. MS. fide Dyer.*

11. S. stipularis, *Thw. Enum. Pl. Zeyl.* (1859) 36; *Trimen, Fl. Ceylon*, i. 118.

B. *Western Peninsula.*

12. S. robusta, *Gaertn. f. Fruct.* iii. (1805) 48, t. 186; *Dyer in Hook. f. Fl. Brit. Ind.* i. 306; *Brandis, For. Fl.* 26, t. 9.

The Sāl-tree has two large areas of distribution—at the foot of the Himalaya from lat. 32° in the Kangra district of the Punjab to long. 93° in the Tezpur district of Assam, and on the hills of Eastern Central India as far west as the Pachmarhi hills, extending south to near the Godavery river.

Flowers in unilateral racemes, these arranged distichously.

Stigma 3-dentate. Cotyledons thick, fleshy, bifid to base, furrowed on the outside. The short radicle and the well-developed petioles, these $\frac{1}{3}$–$\frac{1}{2}$ inch long, lie between the two lobes of the outer cotyledon, which is more or less concave, embracing the inner or placentary cotyledon, between the lobes of which the lignified placenta and the remains of the dissepiments intrude. According to Pierre, *l. c.* tab. 243, the cotyledons of *S. robusta* are "huileux." I have always found the cells filled with starch.

In herb. Kew are specimens of leaves and fruit communicated by M. Pierre, no. 1690, from Cambodia. The leaves resemble those of *Shorea robusta*, and the cortical leaf-traces seem to be short, but the fruit is different. The fruiting-calyx is glabrous, shining, and only covers the base of fruit. In *S. robusta* the fruiting-calyx is pubescent, and the base of its segments covers the entire fruit. Under tab. 243, which figures *S. robusta* from Indian specimens, Pierre expresses his doubt whether the specimens mentioned should be referred to *S. robusta* or to *S. obtusa*; and under tab. 234 he actually refers no. 1690 to *S. obtusa*. But the nervation of the leaves is different in *S. obtusa*. These specimens somewhat resemble a specimen (leaves only), no. 6563, received at Kew from Hort. Bot. Bog. in 1815, and marked "*S. tomentosa*, Miq., from Siam, cult. in Hort. Bot. Bog." *S. tomentosa* does not seem to have been published.

13. Shorea Tumbuggaia, *Roxb. Hort. Beng.* (1814) 42, *et Fl. Ind.* ii. 617; *Dyer in Hook. f. Fl. Brit. Ind.* i. 306.

Dry districts of the Southern Deccan.

C. *Eastern Peninsula.*

14. S. obtusa, *Wall. List*, 1828, n. 966; *Blume, Mus. Bot.* ii. (1852) 32, t. 8; *Dyer in Hook. f. Fl. Brit. Ind.* i. 306; *Pierre, Fl. For. Cochinch.* fasc. 15, t. 234.—Pl. I. fig. 10.

Eastern Peninsula, not known north of 20° N. lat. In Burma scattered in forest of *Dipterocarpus tuberculatus*; in Cambodia associated with this tree, but also, according to Pierre, forming pure forests by itself.

Flowers in short unilateral racemes, these distichous, forming drooping axillary and terminal panicles. Stigma indistinctly 3-toothed. Embryo similar to that of *S. robusta*, the five abortive

ovules at the top of the lignified placenta. The cotyledons filled with starch-grains.

15. SHOREA THORELII, *Lanessan, Pl. Utiles Col. Fr.* (1886) 302; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 233.

Cochinchina.

Stylopodium elongate, hairy, as well as ovarium.

16. S. VULGARIS, *Lanessan, Pl. Utiles Col. Fr.* (1886) 301; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 232.—Pl. II. figs. 15, 16.

Filaments of the inner stamens thickened above; upon the thickened portion is inserted a short stipes, bearing the anther.

17. S. PIERREI, *Hance in [London] Journ. Bot.* xvi. (1878) 302.

Cambodia.

Incomplete specimens, in young fruit only, in British Museum, similar in appearance to *S. vulgaris*, Pierre. In the 'Fl. For. de la Cochinchine' this species is not mentioned.

18. S. COSTATA, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 119.

Penang.

I find 20 stamens; King says 15.

19. S. UTILIS, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 119.

Penang.

The posterior anther-cells ciliate at top; appendages of connective thick, blunt, a little longer than anther, densely ciliate.

20. S. BARBATA, sp. nova. Arbor, ramulis petiolisque transverse rimosis. Folia discoloria, ovato-lanceolata acuminata, acumine lineari obtuso, supra glabra infra minute tomentosa, nervis secundariis utrinque 8–10, nervis tertiariis approximatis inconspicuis. Flores parvi. Stamina 20–30, antheris apice basique barbatis, connectivi appendice latâ dense barbatâ. Pistillum stylopodio tomentoso, stylo brevi glabro.

Batang, Malacca (*Ridley*, nn. 1784, 1789).

Branchlets dark grey. Leaves matted on the underside with dense greyish-yellow pubescence; blade 2–4, petiole ¾ in. long. Buds ovate. Flowers in short, mostly unilateral spikes, these

regularly alternating and distichous, forming slender terminal and lateral panicles, longer than leaves. Anther-cells unequal, the posterior barbate at base and apex. Appendages shorter than anther, on all sides bearded with long hairs. Stylopodium large, densely tomentose; style short, glabrous; stigma minute. Fruit unknown.

21. SHOREA CILIATA, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 118.

Penang.

Secondary nerves 8–9 pairs; sepals triangular. Buds linear. Petals ½ in. long. Stamens 30, appendage of connective apical, slender, with 3–5 spreading ciliæ. Ovary and stylopodium pubescent; style short, glabrous.

D. *Borneo, Sumatra.*

22. S. SCHEFFERIANA, *Hance in* [*London*] *Journ. Bot.* xvi. (1878) 303.

Sambas, Borneo, "*Teng kawang saloeng soeng.*"

Branches flexuose, leaves chartaceous, oblong-lanceolate. Secondary nerves 12–14 pairs, arching; tertiary nerves very numerous, parallel, close together. Buds linear. Flowers sessile, in slender racemose axillary panicles, shorter than leaf, consisting of short unilateral distichous spikes. Sepals broad, obtuse, grey tomentose outside, glabrous inside. Petals linear, ½ inch long. Stamens 20. Appendage of connective oblique from back of anther, with long ciliæ. Ovary and stylopodium densely tomentose; style short, glabrous. Fruit unknown.

23. S. HAVILANDI, sp. nova. Arbor. Folia elliptica, breviter acuminata, fere glabra, nervis secundariis utrinque 8–10, tertiariis approximatis parallelis et reticulatis in utrâque facie conspicuis. Stamina 40–50, antheris ellipticis, appendice nudâ sed basi valde incrassatâ. Ovarium (cum stylopodio exiguo) pubescens, stylo brevi glabro.

Borneo (*Beccari*, n. 2472; *Haviland*, n. 1899).

Branches with numerous small lenticels. Leaves glabrous on both sides, only midrib with scattered tufts of stellate hairs; blade 3–5 in. by 2–2½ in.; petiole hoary, ¾ in. long. Panicles long, slender, terminal and axillary, consisting of short unilateral spikes distichous and regularly alternating. Buds elongate-conical.

Calyx pubescent outside, glabrous inside. Petals hairy outside, silky inside. Stigma minute. Fruit unknown.

24. SHOREA SCROBICULATA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 207.

Borneo (*Beccari*, nn. 2538, 2889, 2917).

Branchlets black, with scattered small lenticels. Leaves ovate-lanceolate; midrib channelled above, together with the 12–14 pairs of secondary nerves very prominent beneath; tertiary nerves parallel, conspicuous below. Panicles slender, axillary and terminal. Buds linear. Flowers in short unilateral distichous spikes; calyx tomentose outside, glabrous shining inside; petals silky on both sides, with long hairs. Stamens 20–30; appendage of connective not ciliate, but thickened at base. Ovary and small stylopodium pubescent; style short, glabrous; stigma minute. Fruit long acuminate, tomentose; wings of the fruiting-calyx membranous, pubescent, the three longer 2–3 in. long, with 6–8 longitudinal nerves joined by prominent transverse and reticulate veins.

25. S. FUSCA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 207.

Sumatra (?) (*in Herb. Lugd.-Bat.*).

"Stam. plus quam 30, connectivo breviter producto. Ovarium glabrum, stigmate 3-lobo" (*Burck*).—[Not seen.]

This has been placed here because Burck places it near *S. scrobiculata.* He quotes doubtfully Maingay's 202 from Malacca, which is *S. sericea*, Dyer. According to Burck, *S. fusca* has leaves with a rounded or truncate base, ovate deciduous tipules leaving a circular scar, few-flowered axillary racemes. This does not tally with Maingay's specimens. The glabrous ovary and the 3-lobed stigma rather point to *Anthoshorea*, sect. *Hopeoides.*

E. *Philippine Islands.*

26. S. VIDALIANA, sp. nova. Arbor, ramulis pubescentibus. Folia oblonga, brevissime acuminata, inferne pubescentia, petiolis pubescentibus, nervis secundariis utrinque 12, nervis tertiariis inconspicuis. Paniculæ longæ, nutantes, ramis tenuibus. Stamina connectivi appendice validâ longe ciliatâ. Ovarium cum stylopodio cylindrico pubescens.

Luzon, district Morong (*Vidal*, n. 984).

Inflorescence, petioles, midrib, and secondary nerves on the underside of leaf pubescent; hairs often long and slender.

Leaf-base rounded or slightly cordate; blade 2–3 in. long, 1–1¾ in. broad; petiole ½ in. Panicles axillary, longer than leaf, ramifications almost filiform. Appendages of connective with 3–7 long ciliæ. Stylopodium nearly twice the length of ovary, both hairy; style short; stigma minute.

In habit somewhat resembles *Shorea philippinensis* of section *Anthoshorea*; but the oblong leaves and filiform branches of the inflorescence distinguish it.

Sect. III. ANTHOSHOREA.

Fruiting-calyx with 3 long wings. Flowers large; stamens generally 15–17, in a few species 23–30; anthers oblong, connective terminating in a long, filiform, naked appendage, sometimes scabrous at the end. Ovary mostly glabrous; style longer than ovary; stigma generally 3-dentate; no stylopodium.

1. *Anthoshorea*, Heim.—Stamens 15–17.

A. *Western Peninsula.*

27. SHOREA TALURA, *Roxb. Hort. Beng.* (1814) 93, *et Fl. Ind.* ii. 618; *Dyer in Hook. f. Fl. Brit. Ind.* i. 304.

Eastern drier districts of the Deccan.

Glabrous, only petals pubescent on the outside, and sepals ciliate on edges. Leaves elliptic-oblong, 3–4 in. long; petioles ½–1 in. Secondary nerves 10–14 pairs, tertiary finely reticulate. Flowers light pink, on short pedicels in drooping axillary panicles, with slender, almost filiform ramifications. Anthers of the five interior stamens longer than the others; filaments thickened at base. Appendage of connective equal to anther, scabrous at the end. Ovary glabrous, narrowed into slender style as long as ovary; stigma 3-fid. Wings of fruiting-calyx with 10–12 longitudinal nerves and prominent oblique transverse veins, narrowed below; base entirely enclosing the fruit.

B. *Eastern Peninsula.*

28. S. COCHINCHINENSIS, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 230.

Siam, Cambodia, and islands of Lower Cochinchina (*Pierre*).

Differs from *S. Talura* only by longer petioles, up to 1½ in., and by the sepals pubescent outside as well as on the inside near the apex.

29. SHOREA FLORIBUNDA, *Kurz MS. e Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 304.—Pl. II. figs. 19, 20.

Tavoy (*Wallich*, n. 964); Tenasserim (*Helfer*, anno 1838 lecta).

Leaves from an acute base, elliptic-oblong; lateral nerves 12–16 pairs; calyx glabrous. Ovary glabrous.

The three last-named species—*Talura, cochinchinensis*, and *floribunda*—are so closely allied that the examination of more ample specimens may prove them to be identical.

30. S. HARMANDII, *Lanessan, Pl. Utiles Col. For.* (1886) 302; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 231.

Cochinchina, Laos.

Young leaves tomentose, otherwise similar to the preceding.

31. S. ATTOPOENSIS, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 232.

Laos.

This species, of which the fruit only and leafless branches are known, Pierre places near *S. Harmandii.*

32. S. BRACTEOLATA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 305; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 117.

Malacca; Penang; Perak; Negri Sembilan; Singapore: probably all over the Malay Peninsula; Sumatra (*Forbes*, n. 3050).

Leaves elliptic-lanceolate; secondary nerves 10–16 pairs; tertiary parallel, joined by closely reticulate veins. Smaller segments of fruiting-calyx half the length of the larger segments.

Similar to the three preceding species, but distinguished readily by the semipersistent oblong bracts, two under each flower, which enclose the buds, but which fall as soon as the flower opens. The calyx is always pubescent, and the appendage of the connective is longer, to three times the length of anther.

33. S. ASSAMICA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 307.

Upper Assam at the foot of the Naga hills, in the Sibsagar and Lakhimpur districts. "*Makai.*"

Young shoots, stipules, and young leaves softly tomentose; stipules lanceolate, subfalcate, $\frac{2}{3}$ in. long. Flowers $\frac{1}{2}$ in. long, on very short pedicels; sepals and petals hairy outside, glabrous inside. Stamens 15, with long glabrous appendage. Ovary and base of style hairy; style filiform, longer than ovary; stigma 3-partite.

34. SHOREA MAXWELLIANA, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 114.

Perak.

C. *Borneo and other Islands of Indian Archipelago.*

35. S. SELANICA, *Blume, Mus. Bot.* ii. (1852) 33; *Burck in Ann. Jard. Buitenz.* vi. (1877) 216.

Amboina.

Branchlets, petioles, and underside of oblong leaves tomentose. Ovary hairy; style filiform, twice the length of ovary. According to Rumphius (Herb. Amboin. ii. 169), this species (*Dammara Selanica*) produces immense quantities of resin, found in the old wood, between wood and bark, and exuding from the bark, hanging down from the branches in conical or cylindrical masses the thickness of a man's leg. These masses of resin are transparent, resembling amber in colour; and they are often dug out from the ground near the foot of the tree, or washed down to the sea by the rivers when in flood, and afterwards found upon the shore.

36. S. BALANGERAN, *Burck in Ann. Jard. Buitenz.* vi. (1887) 214.—Hopea Balangeran, *Korth. Verh. Nat. Gesch. Bot.* 74, t. 7. —Parahopea Balangeran, *Heim, Recherch. Diptérocarp.* 66.

Borneo: *Korthals* (gregarious on the banks of the Pattai river), *Motley* n. 894, *Beccari* n. 3461; Madjang; Bangka; Luzon (Ins. Phil.), *Cuming* n. 884.

Leaves ovate-oblong, glabrous above, clothed beneath with dense yellowish-brown pubescence. Larger wings of fruiting-calyx thinly membranous, 1–1½ in.

I cannot follow Heim in regard to his genus *Parahopea.*

37. S. FALCIFERA, *Dyer MS.* Arbor. Folia coriacea, ovato-lanceolata, interdum subfalcata, discoloria, nervis secundariis utrinque 8 cum costâ infra conspicuis, nervis tertiariis obscuris. Fructus tomentosus, calycis segmentis basi dilatatis fructum omnino obtegentibus 3 majoribus falcatis.

Borneo (*Beccari*, nn. 2992, 3046; *Motley*, 37 (?)); Lingga (*Teysmann*, n. 12076).

Branchlets pubescent. Stipules small, caducous. Leaves glabrous and shining above, the underside clothed with a dense tawny tomentum of minute stellate hairs; blade 3–5 in.; petiole ⅜ in. Flowers unknown; fruit in axillary and terminal panicles,

acuminate, almost entirely covered by the enlarged base of calyx-segments. Of these segments, the three larger 4 in. long, falcate; longitudinal nerves 8–10, with prominent oblique transverse veins. Cotyledons filled with starch, nearly equal, thick fleshy, the outer slightly concave, partly embracing the inner. Both cotyledons bifid to base, the hypocotyl ($\frac{1}{4}$ length of embryo) with short petioles, between the two lobes of the outer, the lignified placenta with remains of dissepiments between the two lobes of the inner cotyledon.

This species has been placed here on account of the similarity in leaf to *Shorea Balangeran.*

38. Shorea Beccariana, *Burck in Ann. Jard. Buitenz.* vi. (1887) 213.—S. Franchetiana, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 956.—S. Beccarii, *Dyer MS.*

Borneo (*Beccari*, nn. 1126, 1127, 1128, 2480, 2912).

Stipules deciduous, scars semi-amplexicaul. Flowers sessile, in unilateral bracteate spikes, which are distichous and regularly alternating, arranged in long drooping panicles. Two oblong bracts under each flower, enclosing it. Anthers oblong, broader at base; appendage filiform, smooth, longer than anther; filaments broad. Ovary pilose; style as long as ovary; stigma minute.

This species is readily known by what appear to be long cortical leaf-traces running in the bark through the entire length of the internodium, by the bracteate spikes, and by the large (8 in. long) and conspicuously veined wings of the fruiting-calyx.

39. S. Singkawang, *Burck in Ann. Jard. Buitenz.* vi. (1887) 219.—Hopea (?) Singkawang, *Miq. Fl. Ind. Bat. Suppl.* i. 489.

Sumatra (*Forbes*, n. 3049).

The seeds contain fat ("E fructibus materies oleosa exprimitur," *Miq. l. c.*).

40. S. compressa, *Burck, Minjak Tangk.* (1886) 26, *et in Ann. Jard. Buitenz.* vi. (1887) 212, t. 24.

Borneo.

Not seen. From Burck's description, a remarkable species: stipules large; bracteoles single bifid, or in pairs; flowers 18 mm. long, on pedicels 10 mm. long; style thick, cylindric, pubescent; stigma 3-lobed.

D. *Philippine Islands.*

41. Shorea contorta, *Vidal, Sinopsis, Atlas* (1883), 15, t. 15. fig. *e, et Pl. Vasc. Filip.* 61.

Luzon (*Vidal*, nn. 987, 2159).

Leaves glabrous, ovate, acuminate, margin undulate; secondary nerves 6 pairs; tertiary nerves parallel, not conspicuous, joined by reticulate veins. Anthers linear; appendix of connective very short. Ovary glabrous; style cylindric, articulate with ovary, stigma minutely papillose. Wings of fruiting-calyx twisted, very unequal, the two largest 3–5 in. long, with 10–12 prominent nerves, the third $2\frac{1}{2}$ in. long, the others much smaller. Fruit tomentose, acuminate; base of fruiting-calyx pubescent.

Anomalous, on account of the short anther-appendage and the style articulate with ovary.

42. S. polita, *Vidal, Sinopsis, Atlas* (1883), 15, t. 15. fig. *d, et Pl. Vasc. Filip.* 61.

Luzon (*Vidal*, nn. 71, 77, 989, 2155, 2166, 2168).

Leaves glabrous, elliptic and elliptic-lanceolate, slightly undulate, 3–5 in. long, petiole 1 in. Secondary veins 14 pairs; tertiary inconspicuous, parallel, joined by dense reticulate venation. Flowers in unilateral spikes in large terminal panicles, the branches of which are slender. Calyx pubescent, sepals densely clothed with long hairs. Anthers linear, the filaments of the 10 episepalous stamens connate; appendage twice the length of anther. Ovary glabrous, style cylindric, stigma 3-dentate.

43. S. philippinensis, sp. nova. Ramuli pilis stellatis tecti. Folia elliptica, petiolis et paginâ inferiori pilis stellatis obtectis, nervis secundariis utrinque 10–12, nervis tertiariis inconspicuis. Stamina antheris linearibus longe aristatis. Ovarium cum styli basi puberulum, stylo filiformi glabro ovarium excedente.

Luzon (*Vidal*, n. 983).

Petioles and inflorescence pubescent with stellate hairs. Leaves—blade $1\frac{1}{2}$–$2\frac{1}{2}$ in. long, petioles $\frac{1}{3}$ in. Bracts enclosing the buds subpersistent; appendage filiform, longer than anther. Stigma minute.

2. *Hopeoides*, Heim.—Stamens 20–30.

44. S. gratissima, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 307; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 115.

Tenasserim (*Helfer*, n. 714); Singapore (*Ridley*, nn. 4466, 6557).

Glabrous, except inflorescence, calyx, and petals. Flowers on pedicels ⅓ length of calyx, in unilateral distichous racemes, forming large terminal and axillary panicles. Stamens 20–25, the filaments of the inner longer and broader. Appendage of connective much exceeding anther, scabrous towards the end. Style as long as ovary, stigma 3-dentate, top of ovary and base of style slightly puberulous. Wings of fruiting-calyx membranous, linear, the 3 longer 2 in. long, with 10–12 longitudinal nerves, base covering the fruit completely.

45. SHOREA HYPOCHRA, *Hance in* [*London*] *Journ. Bot.* xiv. (1876) 242; *Pierre, Fl. For. Cochinch.* fasc. 15, t. 228.

Cochinchina; gregarious in places.

46. S. HENRYANA, *Lanessan, Pl. Utiles Col. Fr.* (1886) 302; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 229.

Anam; remarkable for large stipules on young trees.

47. S. MARITIMA, *Lanessan, Pl. Utiles Col. Fr.* (1886) 302; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), sub t. 229.

Anam.

48. S. CAMBODIANA, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), sub t. 229.

Anam.

49. S. GUISO, *Blume, Mus. Bot.* ii. (1852) 34; *Vidal, Sinopsis, Atlas*, t. 15. fig. C.—Mocanera Guiso, *Blanco, Fl. Filip.* ed. I. (1837) 449.—Dipterocarpus Guiso, *Blanco, Fl. Filip.* ed. II. (1845) 313.—Anisoptera Guiso, *A. DC. in DC. Prod.* xvi. (pars 2), 616.

Ins. Philippinæ: Mindoro.

The large flowers, the number of stamens (about 30), and the oblong long aristate anthers seem to place this species, of which I have not seen specimens, in section *Anthoshorea*. But it is anomalous, there is no style and no trifid stigma: this induced A. DC. to place it under *Anisoptera*. Vidal, however, figures three larger segments of fruiting-calyx, and says distinctly (Atlas, p. 15) that it is not an *Anisoptera*. Described as a moderate-sized tree, valued on account of its timber.

Sect. IV. Pinanga.

Fruiting-calyx with 3 long wings; stamens 15; anthers short; appendage of connective not ciliate, sometimes scabrous at the end. In many species the cortical leaf-traces run through the whole length of the internodium.

Many species of this section have on the underside of the leaves a peculiar coppery colour. This is particularly noticeable in species with glabrous leaves, such as *Shorea Pinanga*, Scheff., *Gysbertsiana*, Burck, *macroptera*, Dyer, *acuminata*, Dyer, *lepidota*, Bl., *Bakeriana*, Heim, and *pauciflora*, King. The character is not, however, peculiar to this section, for *S. brachyptera*, Heim, *Schefferiana*, Hance, *Singkawang*, Burck, and *Beccariana*, Burck, of sections *Brachyptera*, *Eushorea*, and *Anthoshorea*, show the same peculiarity, as well as *S. Maranti* of section *Mutica*.

A. Series *macroptera*.—Ovary glabrous; stylopodium pubescent; appendage of connective in most species stout, acute, and not much longer than anther.

50. Shorea macroptera, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 308; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 113.—S. Bailloni, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 973.

Perak; Singapore; Borneo (*Lowe*; *Beccari*, n. 2891).

Glabrous, except inflorescence and youngest shoots. Stipules small, caducous. Leaves thick, coriaceous, shining on both sides, elliptic-oblong. Secondary nerves curved, 10–14 pairs; tertiary nerves parallel, but not distinct. Blade 4–6, petiole $\frac{3}{4}$ in. long. Spikes with a tendency to become unilateral by torsion. Buds short, conical. Filaments of the 5 inner stamens longer, the anthers of these with a very minute appendage; appendage of the 10 outer as long as anther. Ovary glabrous; stylopodium as long as ovary, tomentose; style short, filiform. The 3 outer fruiting-sepals broadly auricled, firmly adpressed to the fruit, and here marked by a smooth convex area. The smaller fruiting-sepals often considerably enlarged. Embryo channelled on outside; hypocotyl nearly as long as embryo. Both cotyledons bifid to base, the radicular concave, embracing the other. Cells filled with oil and starch.

The Borneo specimens, including Beccari 2891, do not differ specifically. Structure of embryo of Perak specimens like that described by Heim. Galls resembling cones on this species.

51. Shorea ferruginea, *Dyer MS.* Arbor. Folia oblonga, infra ferrugineo-tomentosa, nervis secundariis utrinque 14, nervis tertiariis tomento obtectis. Fructus calycis segmentis 3 majoribus basi cordatis fructum arcte includentibus.

Borneo (*Beccari*, n. 2604).

Leaves shining above; tertiary nerves parallel, but indistinct. Blade 4, petiole ½ in. long. Flowers unknown. Fruit like that of *S. macroptera*.

Distinguished from *S. macroptera* by the tomentum on the underside of leaves.

52. S. acuminata, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 305; *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 113.

Perak; Malacca (*Griffith*; *Maingay*, n. 205). "Lingga."

Leaves coppery brown beneath; stipules oblong, obtuse, with one principal and 2 or 4 much shorter longitudinal nerves, joined by prominent transverse veins, semipersistent, in tufts at the ends of branches and ramifications of inflorescence. Flowers in short unilateral spikes, these in distichous axillary panicles; appendage as long as anther. Ovary glabrous; stylopodium large, tomentose; style as long as stylopodium, glabrous. On a Malacca specimen swellings or excrescences alongside the midrib, similar to those of *S. leprosula*.

53. S. ovata, *Dyer MS.* Arbor magna. Ramuli pilis stellatis ferrugineis vestiti. Folia ovata, acuminata, infra pilis stellatis ferrugineis vestita, nervis secundariis utrinque 4–6, nervis tertiariis parallelis non conspicuis. Paniculæ axillares et terminales, spicis unilateralibus disticbe impositis. Corolla alba. Stamina connectivi appendice antheram paullo excedente.

Borneo, *Beccari*, n. 3092; Mt. Singhi ("large tree, corolla white"), *Haviland*, n. 2042.

Petioles clothed with ferruginous stellate hairs. Leaves—blade 2–2½ in. long, 1–1½ in. broad. Flowers in unilateral spikes, these distichous. Buds conical, obtuse. Sepals tomentose outside, pubescent near the apex on the inside. The 5 inner anthers on longer filaments. Style cylindric, as long as stylopodium, stigma thickened. Larger sepals of fruiting-calyx 1¼ in. long, membranous.

Beccari's specimens are in fruit, Haviland's in flower, but they belong to the same species.

54. SHOREA FORBESII, sp. nova. Arbor magna, ramulis nigrescentibus pube stellatâ obtectis. Folia tenuiter coriacea, oblongo-lanceolata, supra glaberrima nitida, infra squamulis minutis rotundis lepidota, margine revoluta, stipulis minutis caducis, nervis secundariis utrinque 12 inferne cum costâ valde prominentibus, tertiariis parallelis obscuris. Paniculæ racemosæ, breves axillares et in ramis vetustis provenientes, floribus brevissime pedicellatis a bracteolis 2 persistentibus fultis. Calycis segmenta imbricata, extùs pubescentia, 3 exteriora longiora in acumen lineare intus pubescens prolongata, 2 interiora breviora rotunda intùs glabra nitida. Petala lineari-falcata, extùs tomentosa. Stamina 15–20, filamentis basi dilatatis, antheris brevibus ellipticis, aristâ antheras quater superante. Ovarium glabrum in stylopodium minute puberulum angustatum, stylo brevi glabro.

New Guinea, Sogeri region at 3000 feet elevation (*Forbes*, 861, April 1886).

Flowers pink-cream. Blade 3–4 in., petiole $\frac{1}{4}$–$\frac{1}{3}$ in. long; flowers $\frac{1}{4}$–$\frac{1}{3}$ in. long, buds short, conical; fruit unknown.

55. S. PARVIFOLIA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 305; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 112.

Penang; Perak; Malacca (*Maingay*, n. 206); Singapore.

Secondary nerves 9–12 pairs; tertiary parallel, oblique, some at right angles to midrib. Appendage of connective as long as anther, at first incurved, afterwards deflexed. Style cylindric, shorter than stylopodium.

56. S. SQUAMATA, *Benth. et Hook. f. Gen. Pl.* i. (1862) 193; *Vidal, Pl. Vasc. Filip.* 62.—Hopea squamata, *Turcz. in Bull. Soc. Mosc.* xxxi. 1858 (pars 1), 239; *A. DC. in DC. Prodr.* xvi. (pars 1), 635.

Ins. Philipp. (fl. and unripe fruit), *Cuming*, nn. 883, 892; Borneo, *Beccari*, n. 3010 (ripe fruit).

Leaves coriaceous, from a rounded base ovate-oblong, upperside glabrous, underside rough with tufts of stellate hairs; secondary nerves 14–18, curved, tertiary veins parallel; blade 4–8 in., petiole $\frac{3}{4}$ in. long. Flowers bibracteolate in unilateral spikes, these distichous in long axillary and terminal panicles, bracts oblong-spathulate. Filaments of the 5 inner episepalous stamens with a thick rounded base, upon which the 5 outer episepalous filaments are inserted; appendage of connective slightly

longer than anther. Stylopodium smaller than ovary; style glabrous, twice the length of stylopodium; stigma minute. Larger segments of fruiting-calyx 6–7 in., smaller 4–5 in. long.

The leaves of the Borneo specimens are smaller and more thickly coriaceous.

57. SHOREA GRANDIFLORA, sp. nova. Arbor mediocris, ramulis tomento stellato ochraceo obtectis. Folia magna, obovato-oblonga, superne præter costam nervosque secundarios ochraceo-stellato-tomentosos glabra, stipulis oblongis 5–7-nerviis (cum paginâ inferiore foliorum) tomento stellato ochraceo tectis, petiolo brevi ochraceo-stellato-tomentoso. Flores magni. Stamina antheris longe aristatis. Pistillum ovario pubescente, stylopodio glabro, stylo filiformi quam stylopodium longiore.

Borneo ("small tree, corolla red"), *Haviland*, n. 2121.

Stipules, nerves on the underside of leaves clothed with stellate hairs, midrib and secondary nerves hairy on the upper face also. Stipules subpersistent. Leaves thickly coriaceous, 7–9 in. long, 3–4 in. broad. Secondary nerves 13–15 pairs, arched, joined by conspicuous intramarginal veins, tertiary nerves parallel, prominent, joined by numerous parallel and reticulate veins. Flowers large, petals nearly 1 in. long; filaments of the 5 inner stamens much longer than the others, gradually narrowed from a broad base. Appendage of connective twice the length of anther; style filiform, longer than stylopodium; stigma thickened. Fruit not known.

58. S. KUNSTLERI, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 116.

Perak.

In regard to the glabrous ovary and hairy stylopodium this agrees with the other species of this series; the style is cylindric, as long as stylopodium, but the stigma is trifid, and the appendage of the connective is three times the length of anther. In this series, therefore, *S. Kunstleri* is somewhat anomalous.

B. Series *Gysbertsiana*.—Ovary pubescent, stylopodium glabrous or pubescent; appendage of connective filiform, longer than twice the length of anther.

59. S. GYSBERTSIANA, *Burck, Minjak Tangk.* (1886) 15, *et in Ann. Jard. Buitenz.* vi. (1887) 211, tt. 23, 30. fig. 2.

Borneo.

Stipules broad, semiamplexicaul, leaving an annular scar. Midrib hairy on the upper face. Secondary nerves 15–20 pairs. Flowers subsessile in large bracteate, axillary and terminal panicles; stamens 15; filaments all united in a short tube, the 5 inner longer. Ovary with 5 broad densely tomentose ribs in the upper half, base glabrous; style glabrous, short, conical, its thickened base may be regarded as a stylopodium. Wings of fruiting-calyx 4–5 in. long, 1½ in. broad in middle, tapering to both ends, wrinkled between the 10–12 longitudinal nerves.

A comparison with specimens of the species and of the variety *scabra*, Burck, obtained from Dr. Burck and preserved in the Museum of the Pharmaceutical Society, has enabled me to identify with this species specimens at Kew collected by Mr. Lowe in Borneo, marked "Bunh. Tausanaing, from this a useful oil is extracted."

60. Shorea platycarpa, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 956.

Borneo (*Beccari*, n. 3302).

Ovaries in an advanced stage show a glabrous short filiform style, on a small glabrous stylopodium, and a hairy ovary, which is exceedingly broad in the middle, tapering below into a short stalk with a number of large resin-cavities. The calyx tightly encloses the young fruit, and hence is constricted above its base. Neither flowers nor ripe fruit known, but the species most probably belongs to this group.

61. S. Pinanga, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 350; *Burck in Ann. Jard. Buitenz.* vi. (1887) 211, t. 30. fig. 1.—Pl. II. figs. 17, 18.

Borneo.

Stipules oblong, narrow, leaving a short scar. Secondary nerves 10–12 pairs. Bracts large, obtuse. Appendage many times longer than anther, filaments dilated and united in a short tube. Ovary conical, upper part tomentose, base glabrous; stylopodium elongated, upper part thickened, glabrous, like the short style. Wings of fruiting-calyx 6 in. long, 1¼ in. broad, of nearly the same breadth throughout their length; prominently oblique transverse veins, connecting the 10–12 longitudinal nerves. Cotyledons fleshy, bifid; hypocotyl about half the length of embryo. The larger (radicular) cotyledon embraces the smaller (placentar) cotyledon; the lignified placenta and the remains of

the dissepiments intrude between the two lobes of the inner (smaller) cotyledon.

To this belong the following specimens in herb. Kew, which I have been able to compare with specimens received from Dr. Burck in Mus. of the Pharmaceutical Society of Great Britain:—2 specimens received 1875 from Herb. Hort. Bot. Bog.; 1 do. received 1888; *Beccari* n. 3077, leaf and fruit. No. 3077 is quoted by Burck for *Shorea Gysbertsiana* var. *scabra*; the stipules, however, are narrow and the scar not amplexicaul.

Two specimens (pieces of the same branch) marked 12026 and received from Herb. Hort. Bog. in 1884 have much larger flower-panicles, terminal and axillary, than indicated in Burck's description; the flowers are also on long pedicels, whereas Burck describes them as sessile. Otherwise they agree with *S. Pinanga* in every respect.

62. Shorea Faguetiana, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 975.—S. dryobalanoides, *Dyer MSS. in Herb. Kew.*

Borneo (*Motley*, *Barber*; *Beccari*, 2566, 2954, 2960, 3039).

Leaves perfectly glabrous. Secondary nerves 5–8 pairs; tertiary nerves mostly reticulate. Flowers small, very numerous, on short pedicels, in unilateral racemes, these arranged in large axillary and terminal panicles. Appendage filiform, longer than anther. Ovary and stylopodium pubescent; style short, glabrous. Fruiting-calyx of 5 nearly equal segments, spathulate with 5 longitudinal nerves, and prominent reticulation between, more or less hairy, thickened at base. Fruit elongated, pubescent. Hypocotyl long, cylindric, imbedded between the 4 lobes of the cotyledons, in the longitudinal axis of the embryo (*Heim*).

63. S. parvistipulata, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 974.

Borneo (*Beccari*, n. 2547).

Leaves elliptic-oblong; secondary nerves 15 pairs; tertiary nerves parallel, those near midrib curved, so as to stand at right angles to midrib. Rounded tufts of hairs on the underside of leaf along midrib, secondary and tertiary nerves. Flowers shortly pedicellate, in unilateral racemes, these distichous, forming lateral and terminal panicles; appendage of connective twice the length of anther. Ovary and stylopodium hairy; style shorter than stylopodium; stigma minute.

64. Shorea lepidota, *Blume, Mus. Bot.* ii. (1852) 32; *Burck in Ann. Jard. Buitenz.* vi. (1887) 217.—S. nitens, *Miq. Fl. Ind. Bat. Suppl.* (1860) 488; *Burck in Ann. Jard. Buitenz.* vi. (1887) 219.

Sumatra (*Korthals, Teysmann*).

Branchlets, inflorescence, petioles, and underside of young leaves pubescent with stellate hairs; midrib hairy above. Stipules semipersistent, oblong, with 5 longitudinal nerves. Leaves elliptic-oblong, shortly acuminate, brown beneath. Secondary nerves 14–18, tertiary parallel and prominent. Blade 6 in., petiole ⅝ in. long. Flowers in unilateral spikes, these distichous and regularly alternating in axillary panicles, shorter than leaf. Ovary hairy; stylopodium glabrous.

S. stipulosa, Burck, *l. c.* 220 (*Vatica stipulosa*, Miq.), may possibly belong to this species.

C. *No distinct stylopodium.*

(1) *Appendage of connective stout, acute, and not much longer than anther.*

65. S. Bakeriana, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 974.

Borneo (*Beccari*, n. 3849).

This species resembles *S. Gysbertsiana*, but differs by having the midrib tomentose on both faces as well as by anthers and ovary. Stipules broad, deciduous, leaving an annular scar. Connective very thick, prolonged into a short appendage. Ovary gradually narrowed into a short style, both glabrous.

66. S. rugosa, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 973. —S. verruculosa, *Dyer MSS. in hb. Kew.*

Borneo (*Beccari*, nn. 2638, 2890).

Underside of leaves and young shoots densely covered with tufts of stellate hairs, which on the inflorescences, on petioles and older branches appear as hard protuberances. Buds ovoid, blunt. Flowers small, sessile, in large spreading terminal panicles. Ovary hairy, gradually narrowed into cylindric style with tripartite stigma. Three large wings in fruit, clothed with tufts of stellate hairs, with 7 longitudinal nerves joined by prominent reticulate veins.

67. SHOREA MACRANTHA, sp. nova. Arbor procera, ramulis tomento ferrugineo stellato dense obtectis. Folia parva, e basi cordatâ vel obtusâ ovato-oblonga, breviter acuminata, stipulis oblongis subfalcatis 3–5-nerviis (cum paginâ inferiore foliorum) dense ferrugineo-stellato-tomentosis, nervis secundariis utrinque 12–14 arcuatis cum costâ valde prominentibus, nervis tertiariis parallelis approximatis valde prominentibus. Flores majusculi. Stamina connectivi appendice brevi acutâ. Pistillum ovario glabro in stylum filiformem attenuato.

Borneo ("large tree, flowers sweet-scented"), *Haviland*, n. 2119.

Petioles, underside of leaves, and ramifications of inflorescence densely clothed with ferruginous tufts of stellate hairs; stipules persistent, acute. Petioles short, thickened and ribbed. Leaves 3–4 in. long, $1\frac{1}{2}$ in. broad; secondary nerves joining in the margin. Flowers sessile, $\frac{2}{3}$ in. long, in sessile or shortly pedunculate clusters, these in elongated axillary and terminal panicles, each flower subtended by 2 bractlets. Calyx and petals tomentose on the outside, glabrous inside. The 5 inner anthers on long, broad, flat filaments. Anthers nearly circular with equal valves. Style glabrous, with a broad stigma. Fruit unknown.

The leaves somewhat resemble those of *S. rugosa*, Heim, but flowers much larger, petioles short, and ovary glabrous.

(2) *Appendage of connective long, filiform, generally twice or three times the length of anther.*

68. S. CRISTATA, *Brandis*.—S. Dyeri, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 957, non *Trimen*.

Borneo (*Beccari*, n. 2515).

Tertiary nerves parallel, conspicuous on upperside. Flowers sessile, each subtended by 2 bracts, in elongated branching spikes, at the ends with tufts of buds and bracts. The 5 inner anthers on long, flat, and broad filaments. Ovary hairy, gradually narrowed into filiform style, which is hairy at the base and exceeds the ovary three times in length. Stigma minute.

Somewhat resembles *S. squamata*, but differs by the inflorescence, the long appendage of connective, and the absence of the stylopodium. *S. Dyerii* is a species of section *Eushorea*, established by Thwaites, and published posthumously in 1885.

69. SHOREA FURFURACEA, *Miq. Fl. Ind. Bat. Suppl.* (1860) 488; *Vidal, Pl. Vasc. Filip.* 62; *Burck in Ann. Jard. Buitenz.* vi. (1887) 219.—S. eximia, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 349; *Burck in Ann. Buitenz.* vi. (1887) 218; *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 121.—S. sublacunosa, *Scheffer in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 350.

Malay Peninsula (Ayer Punnus), *Griff.*, nn. 5018, 5019, specimens infested with galls, *cf.* King, l. c. 122. Sumatra (*Teysmann*). Ins. Arch. Ind., Bangka, Dindang, Bintang (*Teysmann*). Luzon, prov. Albay (*Cuming*, n. 880; *Vidal*, nn. 1120, 2162).

Branchlets, stipules, petioles, underside of leaves, and ramifications of inflorescence with tufts of stellate hairs, which sometimes are very long. Stipules broad, semipersistent, triangular-ovate, longer than petioles, with 7 longitudinal nerves. Leaves thin, nearly membranous, on short petioles, elliptic-oblong, sometimes oblanceolate, shortly acuminate. Secondary nerves 14–22 pairs, arching; tertiary parallel, prominent. Flowers sessile, in secund bracteate spikes, each flower subtended by two unequal bracts. Ovary pubescent, narrowed into glabrous filiform style, much longer than ovary; stigma minute. Fruiting-calyx with three wings 4–5 in. long, narrowed below, but base dilated, tightly enclosing the fruit; transverse veins and 7 longitudinal nerves prominent. Flowers only on the Philippine specimens, which have shorter, elliptic leaves, and are perhaps specifically different.

70. S. WARBURGII, *Gilg in Engler Bot. Jahrb.* xviii. *Beibl.* n. 45 (1894), 38.

North Luzon (*Warburg*, n. 12399).

Flowers in unilateral spikes; these distichous, forming axillary and terminal panicles. Appendage of connective filiform, as long as anther. Ovary tomentose, narrowed into filiform style. Fruit unknown.

71. S. PAUCIFLORA, *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 116.

Penang, Singapore.

Branchlets, petioles, and underside of leaves scabrous with minute stellate hairs. Secondary nerves 10–12 pairs, slightly arching; tertiary very numerous, parallel, curved, and often at right angles to midrib. Flowers on short pedicels, in few-flowered axillary and terminal panicles; appendage of connective towards the apex rough with minute hairs. Ovary glabrous at

base, tomentose in the upper part; style filiform, much exceeding ovary; stigma minute.

72. Shorea gibbosa, sp. nova. Arbor, ramulis rugosis. Folia submembranacea, ovata acuminata, glabrescentia, inferne scabra, nervis secundariis utrinque 8. Calycis segmenta basi incrassata, margine ciliata. Stamina 5 intima filamentis gibbosis, connectivi aristâ longissimâ. Pistillum ovario pubescente, stylo filiformi ovarium bis superante.

Singapore (*Ridley*, n. 6079).

Branches conspicuously wrinkled; young shoots, ramifications of inflorescence, and underside of youngest leaves with minute stellate pubescence. Adult leaves glabrous, but on the underside rough with small protuberances. Leaves 4 in. by 2 in.; tertiary nerves distant and inconspicuous. Flowers on short pedicels, distant, in few-flowered secund racemes, these distichous. Sepals velvety outside, glabrous inside. Petals linear, with a broad basis, puberulous outside, glabrous inside. The filaments of the 5 inner stamens gibbous on the outside. Below this protuberance are inserted the 5 episepalous stamens of the outer circle. Appendage of connective filiform, three times the length of anther. Ovary puberulous, narrowed into style, which is twice the length of ovary. Fruit unknown.

Somewhat resembles *S. pauciflora*, but is readily distinguished by the venation of the thinly coriaceous leaves. Until the fruit is known, its position must remain somewhat uncertain.

73. S. Ridleyana, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 115.

Perak.

Nearly glabrous; tertiary nerves parallel and reticulate, but very inconspicuous. Sepals pubescent on the in- and outside. Appendage of connective denticulate towards the apex. Ovary glabrous at base, hairy in upper part; style very short, glabrous.

D. Species resembling those of this section in habit, but which for want of flowers cannot be classed.

74. S. elliptica, *Burck in Ann. Jard. Buitenz.* vi. (1887) 215.

Borneo (*Beccari*, n. 2574).

Resembles in habit *S. rugosa*, Heim, but the underside of leaves has a dense tomentum of minute stellate hairs.

75. SHOREA CORIACEA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 214.

Borneo (*Beccari*, n. 2948; *Haviland*, n. 485).

Marked by long petioles and recurved edges of the thickly coriaceous leaves.

76. S. TEYSMANNIANA, *Dyer MSS. in herb. Kew.*

Bangka (*Teysmann*, marked *Hopea fagifolia*, Miq.).

Glabra. Folia ovato-oblonga, acuminata, infra lucida brunnea, stipulis parvis caducis, nervis secundariis utrinque 10–14, nervis tertiariis parallelis tenuibus conspicuis.

Leaf-blade 5–6 in. long, petiole ½ in. long.

Sect. V. MUTICA.

Fruiting-calyx with 3 long wings. Anthers of inner stamens or all inappendiculate.

77. S. LEPROSULA, *Miq. Fl. Ind. Bat. Suppl.* (1860) 487; *Burck in Ann. Jard. Buitenz.* vi. (1887) 215; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 110.

Malacca (*Maingay*, nn. 203, 1601); Perak (*Dr. King's collector*, nn. 7646, 8132); Singapore (*Ridley*, nn. 6387, 5074, "local name Meranti"); Sumatra (*Teysmann*); Borneo (*Beccari*, n. 2952).

A large tree 150 feet high; leaves rich deep green, grey underneath; flowers light yellow, silvery grey outside; fruit pale green with a silvery gloss; wings pale yellow (Perak, *Dr. King's collector*). Leaves elliptic and elliptic-oblong; underside tomentose or with rounded tufts of stellate hairs, particularly on midrib and nerves. Secondary nerves 14 pairs; tertiary numerous, parallel. Flowers sessile, unilateral and alternating in two rows, each subtended by two ovate obtuse bracts, so that there are four rows of bracts on the front side of the spike. Stamens 15, the 5 inner anthers without appendage, on long and broad filaments, the 10 outer generally with short appendages, on short filaments. Ovary glabrous, the epidermis with very minute protuberances; style filiform, longer than ovary; stigma minute, no stylopodium. Fruit hairy, acuminate, ⅓ in. diam., tightly enclosed by the enlarged base of fruiting sepals, when ripe the upper portion free. The three outer segments 3 in. long., the two inner 1 in. long, linear. A remarkable instance of a glabrous ovary and a hairy fruit. Testa membranous; cotyledons equal, both bifid to base; hypocotyl as long as embryo, lying in the

middle between the 4 lobes of the cotyledons, the cells of these filled with oil and a little starch.

This species is much infested with galls of various shapes, resembling wingless fruits or cones with pointed scales. On the leaves are round hairy galls, and along midrib and base of secondary nerves are curious swellings, which probably are galls, and which it would be interesting to examine on the spot. These swellings are hollow, consisting of several longitudinal compartments, and the walls of these compartments are clothed with long slender stellate hairs.

78. SHOREA MARANTI, *Burck in Ann. Jard. Buitenz.* vi. (1887) 217; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 120.—Hopea? Maranti, *Miq. Fl. Ind. Bat. Suppl.* 489.

Malacca (*Griffith*); Croping and Sunga Rhya (*Dr. King's collector*, nn. 796, 880); Sumatra (*Teysmann*); Bangka, "Meranti."

Flowers not seen. Burck does not say whether anthers are exappendiculate The leaves differ from those of *S. leprosula* by the perfectly glabrous copper-coloured underside. Similar galls and excrescences along midrib. Possibly not specifically distinct.

79. S. SERICEA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 306; *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 111.

Malay Peninsula (*Maingay*, n. 202); Borneo (*Beccari*, n. 2603).

Leaves oblong, acuminate, sometimes obovate-oblong; secondary nerves 20–22 pairs; tertiary parallel, prominent beneath. Tufts of stellate hairs on underside of midrib, nerves, and veins. Inflorescence like *leprosula*, but bracts unequal, the smaller on the front side. Stamens about 40, mostly without appendix. Ovary glabrous below, continued into long hairy stylopodium, terminating in a short glabrous style and furrowed obconical stigma.

80. S. CURTISII, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 111; *Dyer MS.* fide *King*.

Penang.

Buds enveloped in large bracts, which fall when the flowers open. Stamens 15; anthers ovoid-globose, not apiculate. Ovary glabrous at base, tomentose in the upper part; style short, glabrous. Fruit tomentose, elongated, almost cylindric, base only enclosed by the enlarged base of wings. Embryo similar to that of *S. leprosula*, but cotyledons unequal, containing starch.

81. SHOREA GLAUCA, *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 117.

Penang.

Anthers inappendicalate, ciliate at apex, opening at the top; filaments much dilated in the lower part, which is hairy. Ovary, with short stylopodium, tomentose; style glabrous; stigma capitate, obscurely 3-dentate. Cotyledons both bifid to base, the outer larger and slightly concave; hypocotyl half the length of seed. Cotyledons filled with starch and oil.

82. S. INAPPENDICULATA, *Burck in Ann. Jard. Buitenz.* vi. (1877) 206.—Pl. II. figs. 21, 30.

Borneo (*Beccari*, n. 3009).

Anthers oblong, inappendiculate, or with a very short mucro, ciliate at top, on long filaments, which are broad and hairy. Ovary glabrous; stylopodium broader than ovary, hairy; style short, glabrous. The oblong leaves somewhat resemble those of *S. costata*, King (*Eushorea*), but the tertiary nerves here are parallel, while in *S. costata* they are mainly reticulate.

83. S. RIGIDA, *Brandis in Hook. Ic. Pl.* tab. 2402.

Singapore (*Ridley*, n. 6393).

Stamens 50; anthers nearly circular on long filaments, connate at base and adhering to petals. Stylopodium elongate, hairy; stigma broad, 3-lobed.

84. S. SCUTULATA, *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 110.

Penang.

This species is provisionally placed in this section in deference to Dr. King's statement, "anthers inappendiculate." In bud I have invariably found a short pointed apical appendage. When the pollen is shed, this appendage either falls off or bends down, so as not to be easily seen. All filaments are broad, flat, the 5 inner much longer than the outer. There is a distinct stylopodium, which is tomentose. The ovary is glabrous, with 5 hairy longitudinal ridges. Style as long as stylopodium, glabrous. In the axils of the secondary nerves are scaly swellings, perhaps analogous to those noticed on the leaves of *S. leprosula*, Miq.

The following species, of which I have not seen specimens, could not be placed in sections :—

85. SHOREA LONGISPERMA, *Roxb. Fl. Ind.* ii. (1832) 618.
Penang.

86. S. MALAANONAN, *Blume, Mus. Bot.* ii. (1852) 34; *A. DC. in DC. Prodr.* xvi. (pars 2), 631.—Mocanera Malaanonan, *Blanco, Fl. Filip.* ed. I. (1837) 858.—Dipterocarpus Malaanonan, *Blanco, Fl. Filip.* ed. II. (1845) 312.
Philippines.

87. S. OVALIS, *Blume, Mus. Bot.* ii. (1852) 33; *A. DC. in DC. Prodr.* xvi. (pars 2) 631; *Burck in Ann. Jard. Buitenz.* vi. (1887) 219.
Borneo.

88. S. PALEMBANICA, *Miq. Fl. Ind. Bat. Suppl.* (1860), 487; *Burck. in Ann. Jard. Buitenz.* vi. (1887) 219.
Sumatra.

89. S. SUBPELTATA, *Miq. Fl. Ind. Bat. Suppl.* (1860) 488; *Burck in Ann. Jard. Buitenz.* vi. (1887) 219.
Sumatra.

8. PARASHOREA, *Kurz.*

Sepals on the edge of a broad receptacle, almost valvate in bud. Stamens 15; anthers linear, on short filaments, the connective more or less prolonged; anther-cells more or less unequal, the two posterior shortly beaked. Ovary hairy. Fruit tomentose, acuminate. Five nearly equal wings, narrowed below, not enclosing the fruit.

In *P. stellata*, Kurz, the pith of a leaf-bearing internode contains about 15 resinous ducts. Three leaf-traces as in *Shorea*, the two lateral separating from the central cylinder in the upper portion of the internode. In the petiole a semicircle of 5 vascular bundles, each with a resin-duct; no ducts in the central mass. Of *P. lucida*, Burck, l. c. 221, says that in regard to its anatomical characters it stands between *Vateria* and *Isoptera*.

Apart from the valvate calyx, the species known have a marked similarity in the leaves, which are glabrous on both sides, elliptic-ovate, with 8–10 secondary nerves, the tertiary nerves numerous, parallel, not conspicuous, petioles $\frac{1}{3}$–$\frac{1}{4}$ length of blade. Four species known, 1 from the Eastern Peninsula, 1 from Sumatra, 2 from the Philippine Islands.

1. Parashorea stellata, *Kurz in Journ. Asiat. Soc. Bengal*, xxxix. 1870 (pars 2), 66; *Pierre, Fl. For. Cochinch.* fasc. 14, t. 224.—Shorea stellata, *Dyer in Hook. f. Fl. Brit. Ind.* i. 304; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 120.—Pl. II. figs. 11, 12.

Lower Burma, scattered in evergreen forests; Perak; Cochin-china.

Sepals valvate, tomentose outside, densely pubescent on the inside. Anthers hirsute; prolongation of connective short, obtuse; anterior anther-cells considerably shorter than the posterior. Ovary globose, prolonged into a cylindric furrowed style; no stylopodium. Radicle short, cotyledons petiolate, the outer concave, partly enclosing the inner, which is bifid, and encloses between its lobes the lignified placenta and the remains of dissepiments, the 5 abortive ovules being at the top of the placenta. Cells of cotyledons closely packed with small starch-grains, with a few oil-drops.

2. P. lucida, *Kurz in Journ. Asiat. Soc. Bengal*, xxxix. pars 2 (1870), 66.—Shorea lucida, *Miq. Fl. Ind. Bat. Suppl.* 487.

Western Sumatra.

Tertiary nerves somewhat more prominent than in the other species; three wings of fruiting-calyx longer than the others.

3. P. plicata, sp. nova. Arbor. Folia coriacea, adulta glabra, elliptica, inter nervos secundarios plicata, stipulis amplexicaulibus deciduis. Flores magni, pedicellati. Calycis segmenta anguste lanceolata, subvalvata. Stamina antheris linearibus glabris loculis posterioribus mucronatis, connectivo in processum longum fusiformem longe acuminatum producto. Ovarium in receptaculum semi-immersum, stylopodio elongato piloso, stylo filiformi exserto glabro. Fructus calycis segmentis elongatis æquilongis.

Luzon (*Vidal*, nn. 76, 990, 2033).

Stipules large. Leaves marked by a distinct fold between the secondary nerves, similar to what is seen in many species of *Dipterocarpus*. In the terminal bud the young leaves are completely enclosed within the amplexicaul stipules, and the tender leaf at that stage consists almost entirely of the closely approximate secondary nerves. Flowers 1 in. long, on thick, when dry, furrowed pedicels, which are half the length of sepals.

Sepals lanceolate, slightly overlapping in bud, grey tomentose outside, pubescent inside. Stamens 15; anthers linear, glabrous; valves nearly equal, the two posterior bluntly apiculate; appendage of connective longer than anther, thick spindle-shaped, with a long point. Ovary-cells half-immersed in the broad obconical receptacle, narrowed into an elongated hairy stylopodium. Wings of fruiting-calyx—the 3 outer broader, 8–9-nerved, with prominent reticulate veins between the longitudinal nerves, similar to the venation in the fruiting-sepals of *P. stellata* and *P. lucida.*

4. Parashorea Warburgii, sp. nova. Fructus globosus, acuminatus, tomentosus, calycis segmentis 3 maximis 8–10-nerviis basin versus angustatis 2 paullo minoribus, pericarpio tenui crustaceo, cotyledonibus æqualibus usque ad basin bifidis.

Philippine Islands: Mindanao, plain forest of Dagatpan (*Warburg*).

Only fruit known, which, however, undoubtedly belongs to this genus. Fruit on a thick obconical pedicel $\frac{1}{4}$ in. long, globose, $\frac{3}{4}$ in. diam., tomentose, with the remains of a slender tomentose stylopodium $\frac{1}{3}$ in. long. The three larger wings of fruiting-calyx up to 5 in. long and $\frac{3}{4}$ in. broad; the two smaller segments narrower and $\frac{2}{3}$–$\frac{3}{4}$ the length of the larger segments. Longitudinal nerves of the larger segments 8–10. Pericarp thin, crustaceous. Cotyledons equal, bifid to base, the 4 lobes prismatic with 2 flat and 1 rounded face. Radicle half the length of embryo. Cells of cotyledons closely packed with minute starch-grains.

9. Isoptera, *Scheffer.*

Essential characters:—Calyx-segments imbricate, unequal in flower. Petals linear, many times longer than calyx-segments. Stamens 30–36; anther-cells equal; appendix of connective ciliate. Ovary and stylopodium densely tomentose; style short, glabrous. Fruit supported by the spreading coriaceous sepals, the 3 outer orbicular, larger than the inner. Cotyledons plane-convex, enclosing the hypocotyl, the cells filled with fat.

I have had no opportunity of examining the anatomical structure. According to Pierre (tab. 252) the internode has at its base 16–18 ducts in the pith; near the top of the node two lateral, and afterwards an apical leaf-trace separate from the central cylinder. Burck, *l. c.* 188, states that the resin-ducts of

Isoptera do not anastomose, but are separate throughout their course, terminating in the intercellular spaces of the pith. The petiole has a semicircle of 13–15 vascular bundles, closed by a straight band of xylem and phloëm at the top. The central mass consists of several curved bands of xylem and phloëm with a considerable number of resin-ducts.

Isoptera borneensis, *Scheff. MSS.* ex *Burck in Ann. Jard. Buitenz.* vi. (1887) 222; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 129.

Pahang (*Ridley*); Perak; Bangka, Borneo.

A large tree, which, however, according to Burck (On Minjak Tengkawang, communicated in Pharmaceut. Journal, 1887, p. 902), begins to fruit when about 6 years old, which, according to Mr. Ridley, is also the case in the Malay Peninsula. Leaves oblong; secondary nerves 10–16 pairs, nearly straight at first, curved near the edge of leaf, but without intramarginal veins; glabrous except midrib, which on the upperside is clothed with fine stellate hairs. Flowers in unilateral racemes, these distichous, forming racemose panicles. Fruit spherical, apiculate, tomentose. In Borneo the seeds of this tree yield the fat known as *Tangkawang-terindak.*

10. Balanocarpus, *Bedd.*

(Including *Richetia*, Heim.)

In 1873 Beddome established this genus upon two trees which he had found on the Tinevelly mountains, *B. erosa* and *B. utilis*. The flowers were those of *Hopea*, but the fruit was a hard almost woody nut, oblong or subglobose, with a sharp point at the apex, the lower part enclosed in the enlarged calyx, forming a woody 5-lobed cup, but not expanding into wings. To these two species Trimen in 1889 added (doubtfully) *B. zeylanicus*, and King in 1893 seven others from Malacca, chiefly from Penang and Perak. One of these, *B. penangianus*, King, had previously been described by Heim as *Richetia penangiana*, and another by the same author as *Pierrea penangiana*. The last-named, King called *B. Heimii*.

The distinguishing characters of the genus may now be stated as follows:—Stipules minute, deciduous. Flowers supported by two bractlets, which are sometimes semipersistent, in unilateral racemes, these arranged in compound panicles. Calyx distinctly imbricate on a flat torus; petals generally cohering at the base,

more than three times the length of calyx. *Balanocarpus anomalus*, King, with petals only twice the length of sepals, forms an exception. Stamens 10 or 15, adhering to base of petals; filaments much dilated at base; anthers short ovate; valves nearly equal; connective prolonged into a straight apical awn, longer than anther. Ovary superior, in the majority of species terminating in a fleshy stylopodium, which is either long, cylindric, or short and broad. A number of species, however, have no stylopodium. Style in most species short, in some filiform; stigma minute. Fruit oblong or subglobose, apiculate, often with numerous raised lines, glabrous or hairy; pericarp in some species woody. Segments of fruiting-calyx enlarged and thickened, sometimes woody, enclosing the base of fruit; in several species the outer segments smaller than the inner. Testa membranous, loosely enclosing the embryo. Cotyledons fleshy, generally both bifid. Two types may be distinguished—either the hypocotyl is lying on the outside of the outer cotyledon which is slightly concave, enclosing the inner, or it is lying in the main axis of the embryo, between the 4 lobes of the cotyledons. The first type is found in *B. zeylanicus*, *utilis*, *erosa*, and *Heimii*; the second in *B. penangianus*, *Hemsleyanus*, *Curtisii*, and *coriaceus*.

The secondary nerves are generally distant, more or less prominent on the underside of leaves; the tertiary nerves parallel and reticulate. *B. Curtisii*, however, has numerous indistinct secondary nerves.

For an anatomical examination of *Balanocarpus*, I have not yet had material at my disposal. On tab. iv. of his 'Recherches' Heim represents structure of internode and petiole, and for species 1–3 and 14, which he includes under this genus, the main points, according to that author, are that there are 3 leaf-traces and a small number of resin-ducts in the circumference of the pith, which are pretty large and unequal in diameter. For *Richetia* (species 11–13), Heim mentions gum-cavities in the outer cortex, 6–8 resin-ducts in the circumference of the pith.

As far as can be gathered from the external appearance of herbarium specimens, the length of the cortical lateral leaf-traces varies. In *B. Hemsleyanus* and *Heimii* they appear to run in the bark through more than one internode; in *B. utilis* they are long in some, short in other specimens; while in *B. erosa*, *Wrayi*, and *Curtisii* they are short. It must, however, be remembered that the outward appearance of herbarium specimens is

deceptive in this respect. In the other species they do not show distinctly.

14 species—1 in Ceylon, 2 in the Western Peninsula of India, 7 in the Malay Peninsula, and 4 in Borneo.

A. *Ceylon and Western Peninsula.*

1. Balanocarpus zeylanicus, *Trimen, Fl. Ceylon* (1893), 130, t. 14.—Shorea brevipetiolaris, *Thw. in* [*London*] *Journ. Bot.* xxiii. (1885) 205.—Pl. II. figs. 22, 23.

Ceylon.

Leaves thickly coriaceous, glabrous, ovate or ovate-lanceolate, acuminate, from a cordate, rarely rounded, more or less unequal base. Secondary nerves 6–10 pairs, curved, tertiary mostly reticulate. Stamens 15, anthers on long filaments, the appendage proceeding from the back of connective. Ovary slightly puberulous, narrowed into short cylindric style; no stylopodium. Fruit glabrous, with numerous raised lines. Hypocotyl two-thirds the length of embryo, lying on the outside between the lobes of the outer cotyledon.

2. B. utilis, *Beddome, Forest Man.* (1873) 237, *et Fl. Sylvat.* t. 330.—Hopea longifolia, *Dyer in Hook. f. Fl. Brit. Ind.* i. 309.

Tinevelly hills south of Courtallum, between 1000 and 3000 ft., "*Kara kong*" (Beddome).

Leaves lanceolate, obtuse. Secondary nerves 10–12 pairs, tertiary parallel, visible on both sides of leaf. Flowers $\frac{1}{6}$–$\frac{1}{8}$ in. long; stamens 15; awn twice to three times the length of anther. Stylopodium cylindrical or ovoid, slightly constricted at base; style short. Fruit globose, shortly apiculate, glabrous, shining, veined, but not ribbed. Segments of fruiting-calyx equal, sometimes a little longer than fruit. Both cotyledons bifid; hypocotyl lying on the outside between the lobes of the outer and somewhat larger cotyledon.

A variety with the leaves narrowed into petiole and the tertiary nerves rather prominent, at Kew and at the British Museum, of which the fruit is not known.

3. B. erosa, *Bedd. Forest Man.* (1873) 237, *et Fl. Sylv.* t. 329.

Tinevelly hills, 2000 to 3000 ft.

Leaves from a cordate, often unequal-sided base, oblong-lanceolate. Secondary nerves 12–14 pairs; tertiary reticulate. Flowers $\frac{1}{4}$ in. long. Stamens 15. Ovary narrowed into conical

stylopodium and short style. Fruit ovoid, 1 in. long, glabrous, with numerous longitudinal lines; pericarp as well as thickened segments of fruiting-calyx woody, the two inner being slightly larger than the outer. Hypocotyl three-fourths the length of embryo, lying outside.

B. *Malay Peninsula.*

4. Balanocarpus penangianus, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 131.—Richetia penangiana, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 980.

Penang; Perak.

Flowers $\frac{1}{6}$ in. long, in short unilateral racemes, these distichous, forming racemose panicles. Stamens sometimes 10; anthers small, awn from the back of connective. Ovary without stylopodium, narrowed into short cylindric style. Fruit ovoid, pubescent with numerous raised longitudinal lines. Base of fruit only enclosed by calyx, the two outer segments of which are slightly smaller than the others. Hypocotyl nearly as long as embryo, nearly in the main axis of it, and surrounded by the 4 lobes of the bifid cotyledons. Cells of cotyledons filled with starch. I am unable to follow Heim in his description of the embryo.

5. B. anomalus, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 132.

Kedah, "*Malaut*" (Curtis).

Glabrous, except inflorescence. Leaves ovate; petiole one-third the length of blade; secondary nerves 6–8 pairs, arching; tertiary parallel, often curved, so as to be perpendicular upon midrib, visible on both sides of leaf. Flowers $\frac{1}{8}$ in. long, subsessile, in unilateral spikes, these distichous and regularly alternating, forming racemose panicles. Stamens 10 (*King*), I find 15, arranged in the usual manner; anthers on long dilated filaments; awn as long as anther. Stylopodium short, conical, pubescent; style conical, glabrous, as well as ovary.

6. B. Hemsleyanus, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 134.—Pl. II. fig. 27.

Penang; Perak.

Leaves large, from rounded base elliptic-oblong, thickly coriaceous, underside with tufts of stellate hairs, particularly on the nerves. Secondary nerves prominent, 16–20 pairs; tertiary

parallel, prominent. Flowers sessile, in short unilateral spikes, which are irregularly paniculate. Ovary glabrous; stylopodium cylindric, glabrous; style long, filiform; stigma indistinctly 3-dentate. Fruit tomentose, $1\frac{1}{4}$–$1\frac{1}{2}$ in. long; thickened sepals and pericarp woody, the two outer fruiting-sepals larger. Both cotyledons are bifid to their base, that is to the point where they are attached to the hypocotyl, which is nearly as long as the embryo. The testa loosely envelops the embryo, and is generally partly torn when the seed is taken out from the fruit. In a fold of the testa and between the two lobes of the posterior cotyledon lies the lignified placenta, to which traces of the dissepiments are attached. A similar structure may be observed in the seeds of *Balanocarpus Curtisii* and *coriaceus*.

King justly calls this an anomalous species of *Balanocarpus*, and draws attention to its similarity to several species of *Shorea*, such as *S. eximia* (*furfuracea*) and *leprosula*. The latter, however, has exappendiculate anthers, and the former has no distinct stylopodium. The prominent parallel tertiary nerves are more common in *Shorea* than in *Balanocarpus*, and the section to which this species would most nearly approximate would be *Brachyptera*, with short segments of fruiting-calyx. But the woody pericarp and the loose membranous testa place this species in *Balanocarpus*.

7. Balanocarpus maximus, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 133.

Perak.

Leaves elliptic-lanceolate; secondary nerves 8–10 pairs, arching; tertiary parallel and reticulate. Flowers in short unilateral racemes, which are irregularly paniculate. Stamens 10; filaments three to four times the length of anther, dilated at base. Stylopodium hairy, articulate with ovary; style long, filiform, glabrous. Ovary glabrous, with a hairy ring at top. Fruit cylindrical, $2\frac{1}{2}$ in. long, slightly velutinous, with numerous raised longitudinal lines.

8. B. Heimii, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 133.—Pierrea penangiana, *Heim MSS. in herb. Kew.*

Penang; Perak.

Cortical leaf-traces run through the entire internodium and beyond it; hence branchlets angular. Leaves elliptic-oblong; secondary nerves 8–10 pairs, prominent beneath; tertiary parallel

and reticulate. Flowers unknown. Fruit glabrous, obscurely striate. Radicle short, outside between the two lobes of the outer cotyledon.

9. Balanocarpus Wrayi, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 134.

Leaves elliptic-lanceolate; secondary nerves 7–8 pairs; tertiary parallel and reticulate, obscure. Fruit glabrous. Outer sepals of fruiting-calyx smaller than inner.

10. B. Curtisii, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 131.—Pl. II. fig. 24.

Penang; Perak: fl. Sept., fr. August.

A very pretty small tree, 20–30 ft. high, with glossy bright green leaves. Secondary and shorter intermediate nerves numerous, indistinct; tertiary nerves obscure. Flowers distant, in unilateral racemes, each flower supported by two linear-lanceolate semipersistent ciliate bracts; racemes arranged in lax compound panicles with spreading filiform branches, the lowest flower of a raceme often so near the base as to appear terminal. Stamens 15, the filaments of the inner 5 longer than the anthers. Ovary, stylopodium, and style glabrous; stylopodium short, broad from a narrow base; style short; stigma minute. Fruit globose, apiculate, glabrous, with numerous raised longitudinal lines, entirely enveloped by the slightly thickened sepals, which are as long as the fruit, and of which the two inner are a little larger than the two outer ones. Both cotyledons bifid, attached to the hypocotyl, which, with the short petioles, is nearly as long as the embryo. Cotyledons filled with starch. Outer cotyledon slightly concave, embracing the inner, hypocotyl not on the outside but in the axis of the embryo. Lignified placenta and remains of dissepiments intruding between the lobes of the inner cotyledon, tightly enclosed in a fold of the testa which loosely envelops the seed.

To this species I refer *Hopea bracteata*, Burck (Borneo, leg. Teysmann), as well as Haviland's nn. 1045 and 2225 (Kuching, Borneo, Feb. 1893), all in flower only. The structure of the flowers is identical with *B. Curtisii*, but there is a difficulty in regard to the colour of the flowers. Haviland, no. 1045, says: flowers pale; and no. 2225: petals pale red at the base internally; whereas Dr. King's collector (Perak) states: "flowers very dark blue, almost black, buds have a light blue tip." In the Borneo speci-

mens the pedicels are shorter than the calyx in the same way as in the Perak specimens, but the racemes are often long pedunculate. *Hopea bracteata* and Haviland's no. 2225 have branchlets and petioles pubescent, while no. 1045 is entirely glabrous. The Borneo specimens have large hairy pits at the base of the leaf. Of the Borneo specimens the fruit is not known.

The close affinity of *Balanocarpus* and *Hopea* is well illustrated by this species. The Borneo specimens, of which the flowers only are known, present no external characters that would separate them from section *Dryobalanoides* of *Hopea*. For anatomical examination of this interesting species, no material is unfortunately at present available.

C. *Borneo.*

11. Balanocarpus latifolius, *Brandis.*—Richetia latifolia, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 976.—R. oblongifolia, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 979.

Borneo (*Beccari*, nn. 2511, 2892). Probably also Penang (*Curtis*, n. 426).

Petioles glabrous; tertiary nerves parallel and reticulate; calyx after flowering imbricate, pubescent outside, glabrous inside; sepals thickly coriaceous; (petals and anthers unknown); ovary narrowed into short style, similar to *B. penangianus*; no stylopodium. Fruit cylindric, grey tomentose; base enclosed by the thickened and somewhat enlarged calyx-segments.

12. B. coriaceus, *Brandis.*—Richetia coriacea, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 975.—Pl. II. figs. 25, 26.

Borneo (*Beccari*, n. 2888).

Entirely glabrous, except the fruit; leaves thickly coriaceous, elliptic, acuminate, margin revolute; secondary nerves 5–6 pairs, arching; tertiary nerves parallel and reticulate. Fruiting-calyx enclosing base of fruit, glabrous, shining; segments thickly coriaceous, the two outer a little smaller than the inner. Fruit one inch long, almost cylindric, acuminate, with numerous raised longitudinal lines, slightly velutinous; pericarp crustaceous. Hypocotyl nearly as long as embryo, the cotyledons therefore attached to it at the base of fruit. Both cotyledons bifid to base, thick, fleshy, mainly filled with starch. Hypocotyl lying between the two lobes of the anterior cotyledon, but so as to touch the inner edges of the posterior lobes (fig. 25). Between

the latter intrudes the lignified placenta, to which the remains of the dissepiments are attached. At first sight placenta and dissepiments appear attached to the inside of a membranous cup, which is attached to the endocarp at the base of the fruit (fig. 26). But on closer examination a furrow or fold is seen in the side of the cup mentioned, and it is found that the placenta is enveloped by the remains of the testa, and that the membranous cup is the lower portion of the testa of the one seed which has arrived at maturity, the upper portion having been torn. The testa in this and other species of *Balanocarpus* is not attached to the embryo, but loosely envelops it, and is so thin that it tears when the seed is taken out from the fruit. It gives me great pleasure to state that Dr. Stapf, of the Royal Herbarium, Kew, to whom I showed this peculiar conformation of the seed, drew my attention to the furrow in the basal cup, which I had previously overlooked. In fig. 5 this furrow is not clearly indicated on the right-hand side of the figure. The peculiar feature here is, that at the base of the fruit the testa seems to be attached to the inner surface of the pericarp.

13. Balanocarpus acuminatus, *Brandis*.—Richetia acuminata, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 979.

Borneo (*Beccari*, n. 2942).

Tertiary nerves reticulate, inner segments of fruiting-calyx a little longer than the outer.

14. B. sphærocarpus, *Heim*, *Recherches*, p. 77.

Borneo (*Beccari*, 3021).—[Not seen.]

Near *Balanocarpus*, Heim places a genus established by him upon specimens from Borneo (*Beccari*, 3314) in fruit only, and this fruit without perfect seed—*Pierrea pachycarpa*, Heim, in Bull. Soc. Linn. de Paris, 1891, p. 958; Recherches, p. 78. The fruit is upon a very thick receptacle, enclosed by 5 equal thickened calyx-segments which are nearly as long as the fruit. The pericarp apparently splits into three segments, and while it is thin near the base, is much thickened, woody, in its upper conical part. Regarding the anatomical structure, Heim states that there are two resin-ducts at the base of the internodium, but a larger number higher up, as many as 12 in the lower third, which number again diminishes to 5 in the middle of the internodium. Three leaf-traces enter the petiole, viz. the apical

trace, which is in the bark in the upper fifth of the internodium, and two lateral ones, which run in the bark through the upper third of the internodium. Until more complete specimens of this most interesting tree are available, nothing can be said, except that is seems to stand nearest to *Balanocarpus* and *Shorea*.

IV. VATICEÆ.

11. COTYLELOBIUM, *Pierre, Fl. Forest. Cochinch.* sub tab. 235. (Including *Dyerella*, Heim.)

Trees with thickly coriaceous shining leaves, which are generally perfectly glabrous; in one species only, *C. flavum*, clothed beneath with fine tomentum of minute stellate hairs. Secondary nerves numerous, not very distinct. Flowers in racemose panicles. On the edge of the broad receptacle 5 narrow valvate calyx-segments, tomentose on the outside, and often also on the inside. Stamens 15; anthers oblong or linear, mostly hispid; valves more or less unequal; connective with a short mucro. Ovary free; style filiform or cylindric, longer than ovary. Fruit globose, free; segments of fruiting-calyx unequal; two large wings, the three others smaller. Radicle short, thick; cotyledons divided into numerous lobes. So far as known, starch is the chief non-nitrogenous substance stored in the cotyledons.

Pierre, in tab. 255 H, gives a representation of the structure of internode and petiole of *Cotylelobium Melanoxylon*. I have had no material at my disposal for the anatomical examination of this genus.

A. *Ceylon.*

1. C. SCABRIUSCULUM, *Brandis.* — Vateria scabriuscula, *Thwaites, Enum. Pl. Zeyl.* (1864) 404.—Vatica scabriuscula, *A. DC. in DC. Prodr.* xvi. (pars 2) 620; *Dyer in Hook. f. Fl. Brit. Ind.* i. 303.—Sunaptea scabriuscula, *Trimen, Cat. Ceyl. Pl.* (1885) 9, *et Fl. Ceylon,* i. 126, t. 12.—Dyerella scabriuscula, *Heim, Recherch. Diptérocarp.* 123.

Secondary nerves very numerous, connected by loops of prominent intramarginal veins. Anthers oblong, hispid; style filiform. Cotyledons divided into numerous lobes, attached to a short thick radicle. Cells filled with starch. These are all characters of *Cotylelobium.* Heim acknowledges that the flowers are those of the genus, but draws attention to the large and semipersistent bracts, which are minute and deciduous in the other species of *Cotylelobium.* The genus *Dyerella* he mainly bases upon the

embryo, of which he gives a somewhat different description. A section, however, through the seed near the base of the fruit shows both cotyledons divided into numerous lobes. The anatomical characters relied upon by Heim do not seem to me to be of sufficient importance to separate this species from *Cotylelobium.*

B. *Eastern Peninsula and Borneo.*

2. COTYLELOBIUM MELANOXYLON, *Pierre, Fl. For. Cochinch.* fasc. 14 (1889), sub t. 235; *Heim, Recherch. Diptérocarp.* 120.—Anisoptera (?) Melanoxylon, *Hook. f. in Trans. Linn. Soc.* xxiii. (1862) 160.—Vatica Melanoxylon, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 956.

Labuan, Borneo (*Motley*); Sarawak, Borneo (*Beccari,* 1566, 3139).

A small tree; sap-wood very thin, white; heart-wood very hard and close-grained, light yellowish brown when fresh, quite black when dry and seasoned, with a slight hue of glossy brown.

Next to *Dryobalanops,* perhaps the most valuable tree in Labuan, "Rasak" (*Motley*).

3. C. FLAVUM, *Pierre, Fl. For. Cochinch.* fasc. 16 (1891) t. 258 A.—Vatica Burckii, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 956.—Pl. III. figs. 22–24.

Singapore (*Ridley,* n. 4630); Sarawak (*Beccari,* nn. 3260, 3261, 3389).

Branchlets, petioles, and underside of leaves densely clothed with minute stellate hairs. Leaves thickly coriaceous, elliptic lanceolate, shining above, opaque beneath; secondary nerves very numerous, indistinct; blade 3–5, petiole $\frac{2}{3}$ in. long. Flowers $\frac{1}{3}$ in. long, racemose in terminal and lateral panicles, the ramifications of which, like the calyx, are grey-tomentose. Petals oblong, almost glabrous. Anthers linear, hispid; valves unequal connective prolonged into a short and often bent mucro; filaments short, scarcely dilated at base. Ovary tomentose, as well as the thickened basis of style, which is long cylindric; with a slightly broader and indistinctly 3-toothed stigma. Fruit tomentose, globular, the three smaller segments of fruiting-calyx linear-lanceolate, acute, $\frac{3}{4}$ in. long, the two larger obtuse, narrowed below, 2 in. long.

4. C. HARMANDII, *Heim, Recherch. Diptérocarp.* 122.—Vatica Harmandii, *Heim in Bull. Soc. Linn. Paris,* ii. (1891) 955.

Sarawak (*Beccari,* n. 3132); Kuching, Borneo (*Haviland,* n. 924). I 2

Glabrous, only inflorescence and calyx pubescent. Leaves coriaceous, elliptic; between the 14–18 main secondary nerves, which are joined by prominent intramarginal veins, a large number of shorter intermediate nerves, more or less reticulate. Anthers oblong, hispid: prolongation of connective one-fourth the length of anther. Style filiform, with a thickened tomentose base, twice the length of ovary.

5. Cotylelobium Beccarii, *Pierre, Fl. For. Cochinch.* fasc. 16 (1891), t. 258 B.—Vatica Beccariana, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 955.

Sarawak (*Beccari*, n. 3213).

Very similar to *C. Harmandii.* Heim states the anthers are glabrous; Pierre figures them as slightly ciliate at apex.

No. 467, Sarawak (*Beccari*), leaves only, is very similar to *C. Melanoxylon.* Upon a species collected by Beccari, of which he does not give the number, Heim bases a new genus *Cotylelobiopsis* (Recherch. Diptérocarp. 125). It may possibly be the same as this plant.

12. Vatica, *Linn.*, *Engler, Natürl. Pflanzenfam.* iii. 6. p. 268. Figg. 125, 126.

(Including *Pteranthera*, Blume; *Retinodendron*, Korth.; *Isauxis*, Arn.; *Synaptea*, Griff.)

The large genus *Vatica* cannot, in the present state of our knowledge, be separated into different genera. Its 45 species present a very great variety of characters, but these characters do not march together. The conformation of the fruiting-calyx permits the establishment of three subgenera, viz.: *Retinodendron*, the lobes of the calyx equal, shorter than fruit, spreading or reflexed; *Isauxis*, the lobes equal, longer than fruit and enclosing it; and *Synaptea*, lobes unequal, two forming linear-oblong wings, calyx often adherent to the base of fruit. These characters, however, which are very marked when fruiting specimens are available, are in no way accompanied by other characters, as far as they have been studied: hence it is more convenient at present to regard these subdivisions as subgenera. Eventually, when complete specimens with perfect seeds of a larger number of species are available, it will probably be

found expedient to constitute 3 separate genera. Pierre, l. c. tab. 241, justly relies upon the structure of the seed for separating *Synaptea* from *Vatica*, but in this respect our knowledge is as yet imperfect. *Vatica chinensis* (*Roxburghiana*, Blume) has fleshy, plane-convex cotyledons, both bifid to base, the radicle lying between the two cotyledons. *Vatica obscura*, Trim., has a similar embryo, but, while in the case of *V. Roxburghiana* the radicle is as long as the embryo, the cotyledons being attached to it at the base of the seed, the radicle of *V. obscura* is only half the length of the embryo. A structure similar to *V. Roxburghiana* has the embryo of *V. sarawakensis*, Heim, *V. Ridleyana*, n. sp., and *V. pedicellata*, n. sp.; while *V. lanceæfolia*, Blume, and *V. moluccana*, Burck, more resemble *V. obscura* in that respect. *V. Shumanniana*, Gilg, has similar cotyledons, but an exceedingly short radicle. All these species belong to the subgenus *Retinodendron*. The embryo of *V. Philastreana*, Pierre, of the same subgenus, l. c. tab. 237, is different, and the same must be said of *Retinodendron Scortechinii*, King. Of *Synaptea*, *S. faginea* has thick fleshy cotyledons, both bifid to base, the inner enclosed by the outer, which is curved as in *Shorea* (seeds from Perak and Mergui). Pierre, tab. 242, had possibly unripe seed. Pierre's description of *S. astrotricha*, l. c. tab. 240, agrees with what I have found in the case of *S. faginea*, except that he mentions "un reste d'albumen entre les cotylédons." In the case of *S. Dyeri* he mentions a gelatinous albumen; the embryo, however, is apparently similar to that of *S. faginea* and *astrotricha*. But, as said before, our knowledge of the seed of *Retinodendron* and *Synaptea* is as yet too imperfect to give us safe generic characters for these two groups.

A few words must now be said regarding the names of these three subgenera. King in his materials for a flora of the Malayan Peninsula (Journ. Asiat. Soc. Bengal, lxii. part 2, p. 100), and Trimen in his Handbook to the Flora of Ceylon, accept what has here been called *Retinodendron* and *Synaptea* as distinct genera. King, however, calls the latter *Vatica*, which name Trimen applies to the former genus. I am disposed to agree with Trimen. *Vatica chinensis*, Linn., as figured in J. E. Smith's Icones ineditæ, tab. 36, is undoubtedly *Vatica Roxburghiana*, a tree of the subgenus *Retinodendron*, with short fruiting-calyx, the segments of which are equal. The name *Synaptea* (*Sunaptea* clearly is a misprint) was chosen by Griffith because his *S. odorata* (*Vatica grandiflora*, Dyer) has the calyx slightly

adnate to the base of the ovary. Though this is not the case in all species of *Synaptea,* Griffith's species, with two long wings of the fruiting-calyx, is a proper type of the subgenus *Synaptea.* Pierre, Heim, and, as already mentioned, Trimen regard *Vatica* and *Synaptea* as separate genera. Arnott (Annals of Nat. Hist. iii. p. 155, 1839) made *Isauxis* a subgenus of *Vatica,* to comprise *V. lanceæfolia* and *Roxburghiana.* Burck retained Arnott's name *Isauxis,* but applied it to *V. bancana,* Scheff., with equal but elongated segments of the fruiting-calyx. I follow Burck, and add *V. Kunstleri* and *V. Schefferi* to the same subgenus.

After these preliminary remarks, the essential characters of *Vatica* may now be stated as follows:—

Leaves as a rule coriaceous, petioles generally pubescent. Stipules mostly small, caducous. Secondary nerves distinct and limited in number, tertiary mostly reticulate. Flowers in spikes or racemes, not unilateral, arranged in terminal and axillary panicles. In some species there is what at first sight appears to be a cyme. The axis bifurcates, and there is an apparently terminal flower in the bifurcation. This is found in several species, and it is particularly striking in specimens collected by Dr. Warburg in Luzon (13430) which I refer to *V. Mangachapoi,* Blanco. On closer examination it is found that what appears to be a terminal flower is the lowest lateral flower of the main axis or of the branch which has developed as strongly as the main axis (Plate III. fig. 18, *Vatica perakensis,* King). In *Vatica lanceæfolia* I have found two such pseudo-terminal flowers in one apparent bifurcation, one flower belonging to the axis, the other to the branch (Plate III. fig. 4). The calyx is valvate. Stamens 15, of which 10 are episepalous, standing in 5 pairs behind each other. Anthers short, glabrous; cells very unequal, diverging at the base; appendix of connective obtuse, often very short. Filaments of the 10 outer stamens very short, those of the 5 inner much longer. Ovary either free or half immersed in the obconical receptacle, often pitted, generally hairy; style cylindric, often ribbed and furrowed, mostly shorter than ovary; stigma capitate or conical. Segments of fruiting-calyx either equal, shorter than fruit (*Retinodendron*), or equal and much longer than fruit (*Isauxis*), or two segments growing out into long wings. So far as known, the cells of cotyledons filled with starch.

There is reason to believe that the internal structure of the

different species varies exceedingly. The following remarks must be regarded as preliminary.

At the base of a leaf-bearing-internode are 10–20 resin-ducts in the pith; their diameter is generally small, about 1–3 times that of ordinary pith-cells. As a rule there are hardly any cortical leaf-traces, the lateral and apical leaf-traces separate from the central cylinder within the node or close to the node, and go obliquely across to the petiole. Burck mentions as exceptions to this rule *Vatica borneensis* and *V. faginea.* The petiole below the blade contains a closed ring of xylem and phloëm, with 3–10 resin-ducts on the underside. The central mass of vascular bundles generally consists of 2 curved bands with a few resin-ducts.

Like the other large genera of this order, *Vatica* has representatives over the entire area where Dipterocarps are known to grow. And like *Shorea, Dipterocarpus*, and *Hopea*, the greatest development of forms has taken place in the Eastern Peninsula of India, where 21 species, and in the Indian Archipelago, where 18 species are known, the total number being 45.

Subgenus I. RETINODENDRON, *Korth.*

Prolongation of connective short or long. Stigma as a rule conical, consisting of three or more long, fleshy, conical lobes. Segments of fruiting-calyx equal, shorter than fruit, spreading or reflexed.

A. *Ceylon and Western Peninsula.*

1. VATICA CHINENSIS, *Linn. Mant.* (1771) 242; *Smith, Pl. Ic.* (1789) t. 36.—V. Roxburghiana, *Blume, Mus. Bot.* ii. (1852) 31, t. 7; *Dyer in Hook. f. Fl. Brit. Ind.* i. 302; *Bedd. Fl. Sylv.* t. 95; *Trimen, Fl. Ceylon,* i. 128.—Vateria Roxburghiana, *Wight, Ill.* i. 88.—V. Caddupa, *Buchanan, MS. in hb. Mus. Brit.*

Ceylon, moist low country, common near streams, "Swamp Mendora" (*Trimen*). Forests along the west coast, from South Canara to Travancore. Also in Western Mysore near the crest of the Ghats.

Petioles one-fourth length of blade. Leaves elliptic- and oblong-lanceolate, with rounded base; secondary nerves slightly curved, 10–12 pairs, tertiary mostly reticulate. Flowers on pedicels as long as calyx, arranged in panicles which are mostly axillary and shorter than leaf, and the ramifications of which are clothed with short stellate hairs. Three deciduous bracteoles

under each flower, as well as under the last branches of the panicle. Pedicel 5-ribbed, the ribs alternating with sepals. Anthers shortly apiculate. Ovary with large shallow pits; style nearly as long as ovary, ribbed; stigma densely papillose, obscurely 3-lobed. Pericarp coriaceous, thicker at base than at apex. Testa thin, adhering to endocarp. Hypocotyl with petioles as long as embryo. Cotyledons thick, fleshy, plane-convex, bifid to base. Cells of cotyledons and hypocotyl filled with starch.

2. VATICA OBSCURA, *Trimen, Fl. Ceylon*, i. (1893) 129, t. 13.

Gregarious in the eastern province of Ceylon, "Tumpalai," Tam. (*Trimen*).

Anthers shortly apiculate. Stigma capitate, obscurely 3-lobed. Pericarp coriaceous, $\frac{1}{12}$ in. thick throughout, splits into 3 valves in germination. Testa thin; no remains of placenta, dissepiments, and abortive ovules. Hypocotyl with distinct petioles, half the length of embryo, imbedded in the middle of the embryo between the two cotyledons, which are thick, fleshy, plane-convex, and bifid to base. Starch in the cells of cotyledon and hypocotyl, 6 resin-ducts in the latter.

3. V. AFFINIS, *Thw. Enum. Pl. Zeyl.* (1864) 404; *Dyer in Hook. f. Fl. Brit. Ind.* i. 303; *Trimen, Fl. Ceylon*, i. 128.

Moist low country of Ceylon, rare (*Trimen*).

Anthers ovate-oblong, cells nearly equal, appendage thick, short. Style cylindric, thickened at apex.

B. *Eastern Peninsula.*

4. V. LANCEÆFOLIA, *Blume, Mus. Bot.* ii. (1852) 31; *Dyer in Hook. f. Fl. Brit. Ind.* i. 302.—Pl. III. figs. 2–4.

Assam, in the valley as well as on the hills surrounding it, probably not ascending beyond 2000 ft.; Cachar; Chittagong hills district; Irawadi river in Upper Burma; 2nd Kyaukdweng near Bhamo (*Griffith*).

A large shrub, sometimes growing into a tree. Leaves thinly coriaceous, nearly membranous. One or two pseudo-terminal flowers frequent in a bifurcation of the panicle (fig. 4). Calyx on the outside densely clothed with 1-celled hairs, on the inside with thin pluricellular hairs, valvate in flower, edges overlapping in fruit. Anthers ovate-oblong, each of the 4 cells terminating at base in a blunt beak; appendage of connective thick, cylindric, as long as anthers. Ovary pitted. Fruit ovoid, apiculate, 1–1½

in. long, indistinctly 3-furrowed; pericarp soft, fibrous. Segments of fruiting-calyx broadly cordate, 2 exterior, one overlapping with either the right or the left edge, with 5 longitudinal nerves. Testa thin, loosely enclosing embryo, almost lining the fruit-cavity and enclosing in a fold the short remains of the placenta. Hypocotyl less than half the length of embryo, enclosed by cotyledons, these plane-convex, bifid to base when dry, separating into 4 equal segments. Cells filled with starch.

5. VATICA GRIFFITHII, sp. nova. Præter inflorescentiam glaberrima. Arbor, ramis crassiusculis angulatis. Folia coriacea, elliptico-lanceolata, in petiolum brevem crassum decurrentia, nervis secundariis utrinque 4–7 arcuatis cum intermediis brevioribus alternantibus in nervos intramarginales desinentibus, nervis tertiariis curvatis et reticulatis. Inflorescentia axillaris ramosissima, pilis simplicibus fasciculatisque strigosa, bracteis lanceolatis subpersistentibus, floribus breviter pedicellatis a bracteolis 3 suffultis. Calycis segmenta extùs tomentosa, intus puberula. Stamina antherarum loculis inæqualibus, connectivo crasso in appendicem brevem prolongato. Ovarium irregulariter costatum pilis minutis stellatis vestitum in receptaculo obconico paullum immersum, stylo sulcato, stigmate dense papilloso obscure 3–6-dentato. [Flores suave odorati, petalis luteo-ochroleucis, calyce cinereo-griseo, *Griffith, MS.*], *cf.* Griff. Journals of Travels, 91.—Pl. III. figs. 7, 8.

Upper Burma, Mogoung (*Griffith*, n. 719).

Blade 4–9, petiole $\frac{1}{2}$ in. long. Branches of inflorescence often opposite. After dehiscence the valves of the anthers remain attached to the connective, resembling four unequal-sized membranous wings. This species, which in Hook. Fl. B. Ind. i. 302 has been doubtfully placed under *V. Roxburghiana*, is certainly distinct. The style is longer, the base of the leaf is not rounded, but gradually narrowed into the short petiole. It will doubtless be found again in Upper Burma, and it will be of considerable interest to examine specimens anatomically, for the species of *Vatica* differ much in the structure of internodes and petioles.

6. V. PALLIDA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 302.—Retinodendron pallidum, *King in Journ. Asiat. Soc. Beng.* lxii. pars 2 (1893), 128.

Government Hill, Penang (*Maingay* n. 211, *Curtis* n. 117).

Leaves pale, shining on both sides, glabrous, but petioles puberulous. The lowest flower of a branch often quite at the base, so as apparently to stand in a bifurcation of the panicle. Bracts lanceolate, deciduous. Anthers with short truncate appendix, the 10 outer on very short filaments. Ovary pubescent; style short; stigma capitate, densely papillose. Fruit spherical, terminated by the indurated style. Lobes of fruiting-calyx linear-lanceolate. Dyer in Journ. Bot. 1878, 101, supposed that this might be *Dryobalanops Schefferi*, Hance. The narrow linear segments of the fruiting-calyx makes this impossible.

7. Vatica Scortechinii, *Brandis.*—Retinodendron Scortechinii, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 128.—Pl. III. fig. 9.

Poongah (*Curtis*, n. 2934) (Siam), in the northern part of Malay Peninsula; Pahang (*Ridley*, n. 2438), on the east side of the Malay Peninsula; Perak (*Scortechini*, n. 1940).

Leaves glabrous, secondary nerves 12–16 pairs, curved and terminating in distinct intramarginal veins, alternating with shorter intermediate nerves; tertiary nerves reticulate. Inflorescence, calyx, and outside of petals densely clothed with tawny stellate hairs. Anthers ovate-oblong, connective prolonged into a short conical appendage; the 5 inner episepalous anthers on longer filaments than the 10 outer ones. Ovary stellate-tomentose; style ribbed, as long as ovary; stigma conical, consisting of numerous fleshy linear lobes. Fruit globose, rugose; pericarp thick, hard, coriaceous. Cotyledons thick, fleshy, bifid, on the outer surface with cerebriform furrows. Cells filled with starch.

8. V. Ridleyana, *Brandis in Hook. Ic. Plant.* tab. 2401.—Pl. III. fig. 5.

Singapore (*Ridley*, nn. 2758 *a*, 4449).

Glabrous, except inflorescence, calyx, and outside of petals, which are clothed with minute stellate hairs. Secondary nerves 5–7 pairs, no intermediate nerves; tertiary closely reticulate. Fruit oblong, 2 in. long, obliquely rostrate, verrucose, supported by the indurated, but not enlarged calyx-segments. Cotyledons plane-convex, bifid. The cells filled with starch; hypocotyl as long as embryo.

9. Vatica Philastreana, *Lanessan, Pl. Utiles Col. Fr.* (1886) 299; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 237.

Cochinchina.

Marked by the large reflexed segments of fruiting-calyx. According to Pierre the thick pericarp is fleshy and spongy, the ripe seed contains albumen; hypocotyl short, not enclosed by the thin, but fleshy, somewhat folded, cotyledons.

10. V. Harmandiana, *Lanessan, Pl. Utiles Col. Fr.* (1886) 299; *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 239.—Harmandia flavescens, *Pierre, MS. in Herb. Mus. Brit.*

Laos, on the left bank of the Mekong river.

Fruit not known, but flowers and leaves are those of *V. pallida.* Pierre states that the anatomy of the petiole is slightly different. If it were not for this statement I should have united them. *V. lanceæfolia*, Bl., which Pierre also regards as nearly allied, differs widely by the long appendix of the connective as well as by the consistence and venation of the leaves. According to Pierre these 3 species have in common the small number (2–4) of resin-ducts in the petiole, but this is the case also in *V. obscura*, Trimen, and other species. In specimens of *V. lanceæfolia*, collected by me in Assam in April 1879, I find in the petiole, at the base, on the outside a semicircle of 5 vascular bundles, each with one resin-duct, and in addition to these one resin-duct in the pith of the central halfmoon-shaped vascular bundle, total 6 resin-ducts. For systematic purposes the structure of the petiole must be used with the greatest caution.

11. V. Thorelii, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 238.

Cambodia.

Remarkable for the perfectly glabrous petals. Appendage of connective short, truncated.

C. *Sumatra, and other Islands of the Indian Archipelago.*

12. V. lamponga, *Burck in Ann. Jard. Buitenz.* vi. (1887) 227, t. 29. figg. 3 *a*–3 *d*.

Sumatra.

Connective prolonged into a short pointed appendage; stigma conical, 3-lobed.

13. VATICA FORBESIANA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 228.

Sumatra ?

Fruit crowned with the persistent style and 3-lobed stigma (*Burck*).—[Not seen.]

14. V. MOLUCCANA, *Burck in Ann. Jard. Buitenz.* vi. (1887), 226, t. 26.

Batjan.

Leaves large, to 18 in. long. Secondary nerves 15–20 pairs; tertiary nerves parallel and reticulate; fruit $2\frac{1}{2}$ in. long, pericarp thick, fibrous; calyx reflexed, enlarged, and thickened. Cotyledons plane-convex, bifid to base; radicle half the length of embryo.

15. V. ZOLLINGERIANA, *A. DC. in DC. Prodr.* xvi. pars 2 (1864), 618; *Burck in Ann. Jard. Buitenz.* vi. 226, t. 29. figg. 1 *a*–1 *d*.

Sumatra, Bangka.

Appendage of connective acute; stigma 3-lobed; fruit nearly 1 in. long; pericarp coriaceous; calyx thickened, not enlarged (*Burck*).

16. V. PAUCIFLORA, *Blume, Mus. Bot.* ii. (1852) 31, tab. 7; *Burck in Ann. Jard. Buitenz.* vi. (1887) 226.

Sumatra.

Similar to the preceding, but, according to Blume's figure, stigma capitate, truncate. Fruit unknown, but Burck places it under *Retinodendron*.—[Not seen.]

D. *Borneo*.

17. V. SARAWAKENSIS, *Heim in Bull. Soc. Paris*, ii. (1891) 970.

Sarawak (*Beccari*, n. 3018, fruit). Also collected by Mr. Lowe and, in flower, by Dr. Haviland, n. 1991; Kuching, Sarawak.

Branchlets, petioles, and stipules clothed with large tufts of ferruginous hairs. Leaves large, blade 15 by $4\frac{1}{2}$ in., elliptic lanceolate, acuminate, with cordate base, glabrous, opaque on both surfaces. Secondary nerves 22–26 pairs, arching, more or less joined by intramarginal veins; tertiary nerves, some at right angles to the secondary nerves, others to the midrib, parallel and reticulate. Midrib and secondary nerves very prominent beneath. Petiole $\frac{1}{3}$ in. long. Stipules linear, subpersistent, a little longer

than petiole. The inflorescence, as Heim justly observes, is remarkable—2–4 slender peduncles, each bearing a many-flowered panicle, arise from one leaf-axil, and besides these there are fascicles of interaxillary panicles. As a few of the flowers only produce ripe seed, a number of fruit-bearing peduncles, single or in pairs, are scattered along the entire length of an internodium, as described by Heim. The ramifications of the inflorescences are filiform, with scattered stellate hairs; bifurcations, with an apparently terminal flower, are not uncommon. Flower pedicellate, pale yellow, sweet-scented (*Haviland*); calyx and petals clothed with stellate hairs on the outside; anther-cells unequal; appendage of connective broad, blunt. Ovary hairy; style short, glabrous; stigma conical. Fruit globose, pointed, supported by the enlarged but not thickened sepals, which are reflexed, equalling the fruit in length; cotyledons fleshy, plane-convex; radicle short.

18. VATICA PEDICELLATA, sp. nova. Arbor mediocris. Folia coriacea, oblongo-lanceolata, glaberrima, superne nitida, inferne opaca, petiolis glaberrimis; nervi secundarii utrinque 14–18 nervis intramarginalibus (a margine remotis) juncti, nervis intermediis multis brevioribus, nervis tertiariis reticulatis. Paniculæ axillares et intra-axillares pilis stellatis fusco-purpureis obtectæ, ramis a bracteis 2 parvis deciduis suffultis, pedicello florem fere æquante. Calycis segmenta triangularia, extus pilis stellatis fusco-purpureis tecta, intus pilosa. Petala lineari-oblonga, subfalcata, extus pilis stellatis fusco-purpureis tecta. Stamina 15, 5 interiora episepala antheris minoribus, sed filamentis quam 10 exteriorum longioribus. Ovarium a pilis stellatis tectum, stylo brevi glabro 5-sulcato, stigmate conico. Fructus sphæricus, sepalis auctis (neque incrassatis) fultus. Semen cotyledonibus plano-convexis usque ad basin bifidis, radiculâ embryonem dimidium æquante.—Pl. III. figs. 12–14.

Lundu, Sarawak (*Haviland, d. u. c. d.*).

Blade 5–7 by $1\frac{1}{2}$–2 in., petiole $\frac{1}{4}$–$\frac{1}{2}$ in. Inflorescence often bifurcating, with an apparently terminal flower between the two branches. Stigma consisting of numerous fleshy elongated cones. Fruit $\frac{1}{2}$ in. diam. Cells of cotyledons filled with starch.

19. V. RASSAK, *Blume, Mus. Bot.* ii. (1852) 31.—Retinodendron Rassak, *Korth. Verh. Nat. Gesch. Bot.* 56, t. 8.

River Baritto, Kapoeas &c., Borneo.

Leaves very large, to 27 in. long, resembling those of *V. sarawakensis*, but petioles glabrous or lepidote; tertiary nerves more reticulate, and intramarginal veins not prominent. Differs also by the long cylindrical style and obtuse stigma, and by the reflexed sepals of the fruiting-calyx and the conical, not globular fruit.

20. VATICA OBLONGIFOLIA, *Hook. f. in Trans. Linn. Soc.* xxiii. (1862) 160.—Pl. III. fig. 11.

Petioles very long, up to 2½ in., ¼ the length of leaf; tertiary nerves parallel and slightly reticulate. Inflorescence terminal and lateral. Panicles as well as calyx and petals clothed with dense ferruginous stellate pubescence. Anther-cells very unequal; appendix of connective conical. Ovary 5-ribbed, clothed with minute fasciculate hairs; style 5-ribbed; stigma consisting of 3 fleshy conical pointed lobes. Fruit unknown. To this I refer *V. furfuracea*, Burck (*Beccari*, 2718). The flowers are a little larger, but have the same structure; the petioles are a little shorter. Fruit unknown.

Of the six last-named species, *V. pauciflora*, *sarawakensis*, and *pedicellata* have short petioles; those of *V. Rassak* and *Zollingeriana* are moderately long; while those of *V. oblongifolia* equal the fourth part of the blade.

E. *Celebes.*

21. V. CELEBENSIS, sp. nova. Præter inflorescentiam glabra. Folia elliptico-oblonga brevissime acuminata, coriacea, superne nitida, inferne opaca, nervis secundariis utrinque 10–12, tertiariis reticulatis. Pedicelli calycem æquantes. Calycis segmenta extùs pubescentia, intus leviter puberula. Petala lineari-oblonga, extùs puberula, intus glabra. Stamina 15, filamentis breviter monadelphis, connectivo crasso vix ultra antheram producto. Ovarium pilosum, 5-sulcatum 3-loculare, dissepimentis tenuissimis, stylo glabro sulcato, stigmate conico e lobis multis elongatis conicis constante.—Pl. III. fig. 6.

Lepo-Lepo, on the peninsula south-east of Kandari, Celebes (*Beccari*).

Blade 4–7 in., petiole ¾ in. Fruit unknown.

F. *New Guinea.*

22. Vatica papuana, *Dyer in* [*London*] *Journ. Bot.* xvi. (1878) 100; *Burck in Ann. Jard. Buitenz.* vi. (1887) 229.—Vateria papuana, *Hemsl. Voy. Challenger, Bot.* iii. 123, 287, 296, t. 64 b; *Dyer MS.* fide *Hemsl.*

Ramoi, New Guinea (*Beccari*); Arrow Island (*d'Albertis*). Fruits from the New Guinea drift and sea-beach, Arron Islands.

The fruits from the drift preserved at the Museum, Kew, are $1\frac{3}{4}$ in. long, $1\frac{1}{4}$ in. diam., with 3 furrows down to below the middle. Calyx-segments reflexed, $\frac{1}{2}$ in. long. A thin crustaceous endocarp lining cavity of fruit. Two fleshy cotyledons filled with starch, one thick plano-convex, the other thinner. Leaves and flowers not seen.

23. V. Schumanniana, *Gilg in Engler's Jahrb.* xviii. (1894), *Beibl.* (n. 45) 38.—Vatica papuana, *K. Schum. et Hollr. Fl. Kaiser Wilhelm's Land*, 52, non *Dyer.*

Kaiser Wilhelm's-land, Augusta Fluss (*Hollrung*, 653).

Fruit more ovoid than that of *V. papuana*, fruiting-calyx smaller. Pericarp thick, fibrous spongy. Testa thin; hypocotyl very short, with 9 large resin-ducts; cotyledons thick, fleshy, plano-convex, not bifid. Very thin remains of placenta and dissepiments between the cotyledons, no trace of abortive ovules. Cotyledons permeated by numerous resin-ducts; cells of parenchym filled with starch-grains of different sizes and shapes.

Subgenus II. Isauxis, *Arn.*

Prolongation of connective as long as anther. Stigma consisting of 3 or more short fleshy lobes. Segments of fruiting-calyx equal, longer than fruit and enclosing it.

24. V. Kunstleri, *Brandis.*—Retinodendron Kunstleri, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 129.—Pl. III. fig. 10.

Perak.

A shrub or moderate-sized tree; youngest branchlets and ramifications of inflorescence with stellate hairs. Leaves thinly coriaceous, elliptic-lanceolate. Secondary nerves 7–10 pairs, slightly curved, tertiary reticulate. Pedicels longer than calyx. Axillary

racemose few-flowered panicles, shorter than leaf. Calyx-segments puberulous on both sides. Anther-cells very unequal; connective prolonged into a conical appendage, as long as anther. Ovary pubescent, indistinctly 5-ribbed; style glabrous, cylindric, ribbed, longer than ovary. Fruit glabrous, globular, rostrate.

25. VATICA BANCANA, *Scheff. in Nat. Tidschr. Nederl. Ind.* xxxi. (1870) 348; *Burck in Ann. Jard. Buitenz.* vi. (1887) 229, t. 27.

Bangka, Sumatra.

Style longer than ovary; stigma 5–6-lobed.

26. V. SCHEFFERI, *Brandis*.—Dryobalanops Schefferi, *Hance in* [*London*] *Journ. Bot.* xiv. (1876) 307.

Sumatra, district Lampong (*Scheffer*).

Youngest parts and inflorescence with rusty-brown stellate pubescence. Leaves glabrous, coriaceous, elliptic lanceolate; secondary nerves 12–14 pairs, arching, alternating with shorter intermediate ones; tertiary closely reticulate; blade 4–6 in., petiole ½ in. long. Flowers nearly ½ in. long, on pedicels as long as calyx, in axillary panicles branching from the base. Fruit globose, glabrous, apiculate, ½ in. diam.; segments of fruiting-calyx ovate-oblong, obtuse, glabrous, indistinctly 3-nerved, 1½ in. long, edges of lower half reflexed.

Structure of flowers agrees with *V. bancana*; the two species differ, however, in the leaves and length of fruiting-calyx.

Subgenus III. SYNAPTEA, *Griff.*

Ovary frequently entirely or partially immersed in receptacle. Segments of fruiting-calyx unequal, two expanding into long wings.

A. *Eastern Peninsula.*

1. *Ovary entirely or partially immersed in receptacle; fruit adnate to base of fruiting-calyx.*

27. V. DYERI, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 106.—Synaptea Dyeri, *Pierre, Fl. For. Cochinch.* fasc. 16 (1891), t. 241.—Pl. III. figs. 15–17.

Perak, Cochinchina.

A large tree; leaves coriaceous, elliptic, obtuse; secondary nerves 11–13 pairs; tertiary reticulate. Flowers ⅓ in. long. Anthers adnate to a thick, fleshy connective, prolonged into a

pointed appendage. After the pollen is shed, the 4 valves remain attached to the connective, resembling four thin membranous wings (figs. 15, 16). The same is the case in many other species of *Vatica*. Ovary entirely immersed in receptacle (fig. 17). This does not agree with Pierre's description and figure, but I find it to be the case in the Perak specimens as well those from Cochinchina. According to Pierre, the seeds when ripe are albuminous; I have had no ripe seeds at my disposal.

28. VATICA GRANDIFLORA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 301.—Synaptea odorata, *Griff. Notul.* iv. 516, t. 585 A. fig. 5.—Anisoptera odorata, *Kurz, For. Fl. Brit. Burma*, i. 112.

Martaban; Tenasserim; Singapore.

A moderate-sized tree, with pink sweet-scented flowers. Leaves chartaceous or thinly coriaceous, oblong-lanceolate, acuminate. Secondary nerves 10–14 pairs, tertiary reticulate. Flowers ¾ in. long. Ovary partly, sometimes only slightly, immersed in the receptacle, densely clothed with stellate hairs; style glabrous, as long as ovary, 5-ribbed; stigma broad, consisting of five short rounded lobes. Large resin-cavities in the receptacle, also surrounding ovary-cells. Larger segments of fruiting-calyx oblanceolate, 2½ in. long, with stellate deciduous pubescence; smaller segments lanceolate, one-third the length of the larger.

29. V. FAGINEA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 301; *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 105; *Pierre, Fl. For. Cochinch.* fasc. 16 (1891), t. 242.

Tenasserim; Perak; Cochinchina.

Leaves coriaceous; flowers ½ in. long. Fruiting-calyx glabrous, shining; larger segments linear-falcate, 2½ in. long, the smaller one-fifth the length of larger.

As already noted by Dyer, it seems doubtful whether this is distinct from *V. grandiflora*. In Perak it is a tree 80 to 100 ft. high; in Cochinchina it only attains 15 to 20 metres. Helfer (islands near Mergui) calls it a large forest tree, in full flower in January 1839, very sweet-scented, an ornament of the forest, resembling a pear-tree in full flower. Griffith speaks of it as "frutex vel arbuscula, petalis sanguineis." These discrepancies can only be cleared up by study on the spot in the forest. Like other species of *Vatica*, this produces flowers early in life. In

herbarium specimens the conformation of calyx, petals, stamens, ovary, style, and stigma is the same in *Vatica faginea* and *V. grandiflora*. According to Pierre, the ripe seed contains a little albumen, the embryo is straight, that is the radicle points upward, the cotyledons downward; the radicle is short and the cotyledons are foliaceous. This does not agree with the seeds which I have been able to examine from Mergui and Perak specimens. I find no albumen; the cotyledons are thick, fleshy, both bifid to the point of the attachment to the radicle (hypocotyl), which is nearly as long as the embryo, lying between the two lobes of the outer cotyledon, which is concave, embracing the inner, which however is a little larger.

30. VATICA ASTROTRICHA, *Hance in* [*London*] *Journ. Bot.* xiv. (1876) 241.—Synaptea astrotricha, *Pierre, Fl. For. Cochinch.* fasc. 15 (1890), t. 240.

An important and widely-spread forest tree in lower Cochinchina. Leaves coriaceous; flowers $\frac{1}{3}$ in. long. Two calyx-segments much larger than the others (in flower). Ovary half-immersed, densely stellate-tomentose; style ribbed, shorter than ovary. The larger segments of fruiting-calyx pubescent, $1\frac{1}{2}$ in. long, the smaller $\frac{1}{2}$ in. long. Pierre's description and figure of the embryo agrees with that described from Mergui and Perak specimens of the last species; but he adds that there are traces of albumen in the ripe seed.

The four species last described, *V. Dyeri*, *grandiflora*, *faginea*, and *astrotricha*, form a well-marked group; they are very closely allied, and it is not impossible that further studies on the spot in the forests of Burma, the Malay peninsula, Cambodia, and Cochinchina may show that some of them are only local varieties of a polymorphous species.

The essential characters of this group are:—Dense ferruginous stellate tomentum on branchlets and inflorescence, more or less coriaceous leaves, which are elliptic or oblong-elliptic, with 10–14 pairs of secondary and reticulate tertiary nerves. Flowers sessile or on very short pedicels, the inflorescence a racemose panicle, the ramifications of which are very short while the flowers are in bud, but lengthen out rapidly afterwards. At the time of flowering the branches of the panicle are spikes (or racemes)

with distant, not strictly unilateral flowers. Calyx-segments hairy on both sides, two generally larger in flower. Anthers on short filaments; those of the 5 inner stamens a little longer than the 10 outer; connective thick, fleshy, prolonged into a short appendage. Ovary more or less immersed in the receptacle, the free portion densely stellate-tomentose; style glabrous, ribbed; stigma broad.

31. VATICA RETICULATA, *King, l. c.* 106.
Perak.

32. V. NITENS, *King, l. c.* 104.
Penang.

33. V. CINEREA, *King, l. c.* 104.
Langani, Kedah, Malacca.

34. V. CURTISII, *King, l. c.* 105.
Penang.

2. *Ovary not immersed in receptacle; fruit quite free from calyx.*

35. V. MAINGAYI, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 302; *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893) 104.
Malacca.

Petiole $\frac{1}{3}$ length of blade; tertiary nerves parallel and reticulate; ovary-cells not immersed in receptacle; style slender, as long as stellate-tomentose ovary; stigma consisting of numerous fleshy conical lobes; fruit not adnate to calyx; wings not narrowed at base.

36. V. LOWII, *King in Journ. Asiat. Soc. Bengal,* lxii. pars 2 (1893), 103.
Perak.

A tree, 60–80 feet high; leaves rich glossy green; flowers white and pale green (*Dr. King's collector*). Secondary nerves 13–15 pairs; tertiary nerves mostly reticulate, a few parallel. Sepals in flower unequal; ovary free, tomentose; stigma rounded, consisting of three obtuse fleshy lobes. Wings of fruiting-calyx oblong, $2\frac{1}{2}$ in. long, scarcely narrowed at base, with 5–7 prominent nerves, oblique and reticulate veins.

37. VATICA PERAKENSIS, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 103.—Pl. III. figs. 18, 19.

Perak, Pangkore.

A tree, 60–80 ft. high; flowers light yellow; secondary nerves 10–12 pairs, tertiary nerves reticulate, some parallel, and at right angles to midrib; intramarginal veins prominent. Pedicels as long as calyx or longer; sepals stellate-pubescent, slightly unequal. Ovary free, stellate-pubescent, narrowed into glabrous style, which is ribbed. Stigma conical, nearly as long as style, consisting of three elongated fleshy lobes. The two larger segments of fruiting-calyx oblanceolate, 3 in. long, margin near base reflexed. Fruit crowned by persistent and indurated style.

38. V. SCAPHULA, *Dyer in Hook. f. Fl. Brit. Ind.* i. (1872) 301. —Hopea Scaphula, *Roxb. Fl. Ind.* ii. 611.

Chittagong.

A tree. Petioles 1 in. long, upper half conspicuously thickened; midrib and secondary nerves very prominent, the latter 14–18 pairs, sometimes with shorter intermediate nerves. Tertiary nerves parallel and reticulate. Sepals unequal; petals broadly ovate. Stamens 10; appendage of connective short.

A most remarkable species, which King, *l. c.* p. 127, justly calls anomalous, the anatomical structure of which ought to be studied. Judging from the outward appearance of herbarium specimens, the cortical leaf-traces (very short in all other species of *Vatica*) run through two internodes, the stipular traces uniting with them. The stipules in this species are deciduous, as in all species of *Vatica*; but, judging from the scars, they are larger here than in the other species of this genus.

B. *Java, Sumatra, and Bangka.*

39. V. BANTAMENSIS, *Burck in Ann. Jard. Buitenz.* vi. (1887) 31, t. 28.

Java; Sumatra.

Leaves thickly coriaceous, glabrous, shining on the upper surface. Secondary nerves 8–12, arcuate; tertiary prominent, parallel and reticulate. Larger segments of fruiting-calyx oblong, with 3–5 valid longitudinal nerves and oblique veins, smaller segments ovate. Base of fruit adnate to calyx.

40. VATICA TEYSMANNIANA, *Burck in Ann. Jard. Buitenz.* vi. (1887) 230.

Bangka.

C. *Borneo.*

41. V. HAVILANDII, sp. nova. Arbor, ramulis ferrugineo-tomentosis. Folia coriacea, obovato-oblonga, abrupte acuminata, glabra, petiolis ferrugineo-tomentosis. Paniculæ axillares, folio breviores, ferrugineo-tomentosæ, pedicellis brevissimis, floribus a bracteis binis deciduis fultis. Calycis segmenta triangularia, fere æqualia. Petala linearia. Stamina 15, connectivi appendice lata obtusa antheram fere æquante. Ovarium in receptaculo semi-immersum, in parte libera stellato-tomentosum, stylo sulcato, stigmate elongato-conico. Fructus . . . . .

Kuching; Borneo (*Haviland*).

Secondary nerves 14 pairs, arcuate, with numerous shorter intermediate nerves; tertiary reticulate. Calyx and outside of petals densely clothed with stellate tomentum. Stigma consisting of several long, fleshy, pointed lobes.

42. V. URBANI, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 956. —V. Beccarii, *Dyer*, *MSS. in Herb. Kew.*

Borneo (*Beccari*, nn. 1625, 1969, 2536).

Glabrous, only branches of inflorescence with stellate tomentum; petioles up to 1 inch long and $\frac{1}{4}$ to $\frac{1}{3}$ the length of blade. Secondary nerves not very distinct, 8–10 pairs; tertiary nerves reticulate. Flowers on pedicels, which nearly equal calyx, in terminal and axillary panicles. Sepals unequal, tomentose on both faces. Petals linear, entirely glabrous. Stamens 15; anthers on short filaments, ovate; cells unequal; appendage broad, obtuse. Ovary free, tomentose; style glabrous; stigma capitate, indistinctly 3–5-lobed. Fruit unknown.

43. V. BORNEENSIS, *Burck in Ann. Jard. Buitenz.* vi. (1887) 230.

Borneo (*Beccari*, n. 2623).

Branchlets and petioles clothed with minute stellate hairs.

44. V. BUREAVI, *Heim in Bull. Soc. Linn. Paris*, ii. (1891) 955. —Pl. III. figs. 20, 21.

Borneo (*Beccari*, nn. 3283, 3333; *Haviland*, n. 1946).

Connective thick, fleshy; anther-cells diverging at base; appendage obtuse, longer than anther. Ovary free, tomentose; style glabrous, sulcate; stigma of five round lobes.

D. *Philippine Islands.*

45. VATICA MANGACHAPOI, *Blanco, Fl. Filip.* ed. I. (1837) 401; *A. DC. in DC. Prodr.* xvi. (pars 2) 623; *Vidal, Sinopsis, Atlas,* t. 15 B. figg. 1–6, *et Pl. Vasc. Filip.* 61.—V. apteranthera, *Blanco, Fl. Filip.* ed. II. (1845) 281.—Pteranthera Mangachapoi, *Blume, Mus. Bot.* ii. 30.—Cotylelobium philippinense, *Heim, MS. in Herb. Kew.*

Luzon: San Mateo, Manila (*Vidal*, nn. 69, 70, 72, 78); La Paz, prov. Tarlac (*Vidal*, nn. 68, 75); Boso Boso, distr. Morong (*Vidal*, 74); Sabani, prov. Nueva Ecija (*Vidal*, n. 988); Canderio, prov. Lambab (*Warburg*, n. 13430).

A large tree (*Blanco*). A moderate-sized tree (*Warburg*). Glabrous, excepting inflorescence and young shoots, which are clothed with grey stellate tomentum. Stipules small, caducous. Leaves pale on both sides, coriaceous, lanceolate; blade 3–5, petiole ½ in. long. Secondary nerves 7–9 pairs; tertiary reticulate. Flowers ⅓ in. long, on pedicels nearly as long as calyx, in racemes which are not unilateral, these arranged in terminal and axillary racemose panicles. Pseudoterminal flowers frequent between the main axis and a branch of panicle. Calyx-segments in flower more or less unequal, two larger, on both sides with grey stellate pubescence. Petals linear-oblong, obtuse, hairy outside. The five interior stamens or filaments longer than anthers, the ten outer on very short filaments; prolongation of connective short, conical. Ovary more or less immersed in receptacle, tomentose with stellate hairs; style glabrous, 5-ribbed; stigma of five conical lobes, the two larger segments of fruiting-calyx 2 in. long, linear-oblong, narrowed at both ends, with five longitudinal nerves joined by oblique veins. Fruit (not ripe) globose, tomentose, ⅙ in. diameter, the three cells still visible, one ovule more developed than the others.

After consulting Mr. Rolfe at the Herbarium, Kew, who worked up, with the late Mr. Vidal, the plants collected by the latter, I have decided to accept Vidal's identification, although the following points are against it:—(1) The petioles Blanco

calls short; but with reference to other Dipterocarps they can hardly be called short. (2) Blanco speaks of the ovary as free and stipitate, to which Blume has already drawn prominent attention. (3) Blanco describes the fruit as 3-seeded. Ripe fruit is unfortunately not available; in its unripe condition there is every indication of one ovule only coming to perfection. It must be supposed that Vidal had other reasons for identifying this species with *Vatica Mangachapoi* of Blanco.

No. 73 Vidal, which he quotes as *Vatica* sp. (?), is ***Anisoptera Vidaliana***, Brandis.

13. Pachynocarpus, *Hook. f.*

Leaves thickly coriaceous; tertiary veins always reticulate, Flowers pedicellate, in compound terminal and axillary panicles, the lowest flower of a branch often apparently terminal. Calyx hairy inside and outside; petals linear, much longer than calyx, pubescent outside. Stamens 15 (occasionally 10); anther-cells obliquely adnate to fleshy connective, this prolonged upwards into a short point, and downwards into a thick short filament. After the pollen is shed, the valves of the anthers resemble four spreading thin membranous wings. Ovary slightly immersed in receptacle; style ribbed; stigma broad, bearing numerous papillæ which often are massed in three more or less distinct lobes. Fruit globular, verrucose; walls thick, hard, spongy. Segments of fruiting-calyx equally enlarged and thickened, in most species coalescing with the pericarp, and almost completely enclosing the fruit. Pericarp and calyx-segments adnate to it, thick, of a hard spongy texture, with numerous resin-cavities. Pericarp splitting into segments when ripe. Cotyledons fleshy; cells filled with starch and fat, radicle short.

So far as known, the anatomical structure of ***Pachynocarpus*** agrees with that of ***Vatica***.

Five species—two in the Eastern peninsula, two in Borneo, one in Bangka.

1. P. umbonatus, ***Hook. f. in Trans. Linn. Soc.*** xxiii. (1862), 159, t. 22.—Vatica umbonata, ***Burck in Ann. Jard. Buitenz.*** vi. (1887) 232.—Pl. III. fig. 25.

Borneo (***Motley***; ***Barber***; ***Beccari***, nn. 1104, 3278, 3942; ***Haviland***, n. 1903).

Radicle short, conical, the anterior cotyledon undivided, auriculate at base, emarginate at apex, slightly concave; posterior cotyledon 2-fid to base, slightly smaller. Cells filled with starch and fat, the latter preponderating.

2. PACHYNOCARPUS WALLICHII, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 135.

Penang, Perak, Malacca, Singapore (*Ridley*, nn. 6201–6203, 6205).

A moderate-sized tree, attaining 80 feet, with bright green foliage, waxy yellow flowers, and rusty brown verrucose fruit. Ovary hairy; style 5-ribbed; papillæ on the stigma forming a rounded or conical mass.

3. P. STAPFIANUS, *King in Journ. Asiat. Soc. Bengal*, lxii. pars 2 (1893), 136.

Perak.

Midrib, secondary, and tertiary nerves very prominent on the underside of leaves, some of the latter parallel. Indurated sepals firmly adnate to pericarp; numerous resin-cavities in the thick, hard, spongy, and woody fruit-walls. Pericarp splits into four segments. Cotyledons apparently 3-lobed, filled with starch and fat.

4. P. VERRUCOSUS, *Brandis*.—Vatica verrucosa, *Burck in Ann. Jard. Buitenz*. vi. (1887) 232, t. 29. fig. 5.

Borneo (*Teysmann*).

Ovary 3-lobed; stigma thick, 3-lobed (*Burck*).—[Not seen.]

5. P. RUMINATUS, *Brandis*.—Vatica ruminata, *Burck in Ann. Jard. Buitenz*. vi. (1837) 227, t. 29. fig. 4.

Bangka.

Leaves similar to those of *P. Wallichii*; stigmata 3 (*Burck*). Ripe fruit in herb. Kew nearly 1 in. diam., supported at the base by the thickened and indurated calyx-segments. Pericarp hard, spongy, ¼ in. thick. Cotyledons filled with starch and fat.

Of *Vatica obtusa*, Burck, l. c. p. 228, the author says: "anne rectius *Vaticæ ruminatæ* varietas?" Leaves at herb. Kew received from Herb. Hort. Bog. in 1888, and marked *Vatica obtusa*, Burck, are exactly like those of *Pachynocarpus ruminatus*.

V. VATERIEÆ.

14. Stemonoporus, *Thw.*

(Including *Künckelia*, Heim, *Vesquella*, Heim, and *Sunapteopsis*, Heim.)

Leaves coriaceous; midrib and secondary nerves very prominent; tertiary conspicuous, parallel and reticulate; stipules persistent in *S. Moonii*. Flowers pedicellate; the pedicels often bracteolate, solitary or in few-flowered axillary clusters or racemes. Sepals generally slightly imbricate. Stamens 15; anthers oblong or linear, mostly hispid, with short stiff hairs, the outer valves longer than the inner, opening at the apex; appendix of connective very short or wanting (Engler, Nat. Pflanzenfam. iii. 6. Fig. 127 F, G). Ovary superior, 3-celled, generally pubescent, in most species articulate with long filiform style; stigma minute; no stylopodium. Fruiting-calyx spreading or reflexed, as a rule much shorter than fruit.

The structure of the seed is not uniform. Neglecting minor differences, three types may be distinguished. In *S. affinis* the cotyledons are thick, fleshy, and divided into numerous lobes. A second type is represented by *S. Wightii*. The cotyledons are thick, fleshy, the outer slightly concave, smooth on the outside, on the inside deeply and irregularly furrowed. The inner is divided into three or four lobes. A similar structure have two separate cotyledons preserved in the Kew Museum, and marked *S. acuminatus*. *S. canaliculatus*, Thw., also belongs to this type, as well as, judging by Heim's description, *S. reticulatus*, Thw. (*Künckelia reticulata*, Heim). The third type consists of the albuminous seeds of *S. acuminatus*, Bedd., and *S. oblongifolius*, Thw.

At the base of the fruit-cavity, attached to the inner surface of the pericarp, is a remarkable excrescence (Heim's "cupule chalazique"), a thin fleshy cup, the rim generally divided into numerous lobes. This excrescence is known in the following species: *S. acuminatus*, Bedd., *S. canaliculatus*, Thw., *S. oblongifolius*, Thw. And it is not unlikely that the fibrous mass which is found to intrude between the cotyledons of *S. Wightii* and *reticulatus*, Thw., belongs to a similar excrescence. The morphological character of this remarkable structure, to which Heim has justly drawn prominent attention, can only be determined by the examination of ripe and unripe seeds, fresh or preserved in alcohol.

I have been able to examine the internal structure of internode and petiole of three species—*Stemonoporus Wightii*, Thw. (Herb. Brandis), *petiolaris*, Thw., and *reticulatus*, Thw. (Herb. Mus. Brit.). They all have a considerable number (25–50) of resin-ducts in the circumference of the pith; the ducts are somewhat unequal in size, the largest have a diameter of 10–15 times that of average pith-cells, and they are filled with a solid whitish resinous substance. In the lower half of the internode three of these ducts prepare to enter the wood, which may be seen by a fan-shaped arrangement of the medullary rays. One of these is at the apex of the pith, under the petiole at the top of the internode, the other two are lateral. Contrary to the general rule, the apical duct precedes the two lateral ducts; in the upper half of the internode the apical leaf-trace has separated from the central cylinder and has entered the bark, while the two lateral leaf-traces have not yet been formed. The apical leaf-trace very soon separates, first into 3, and afterwards into 5 distinct vascular bundles, one at the apex and two at each side opposite to each other, thus resembling an impari-pinnate leaf. Eventually the petiole is formed exclusively by the apical leaf-trace. At the node the two lateral leaf-traces have arrived in the bark, and enter the stipules. I have also found branches separating from the apical leaf-trace entering the stipules.

It will be a matter of considerable interest to ascertain whether this peculiar arrangement is common to all species of the genus.

The petiole of *S. Wightii* at the base of the blade has an outer horseshoe of vascular bundles with 16, an inner semicircle with 6, and a central mass with 11, total 33 ducts; that of *S. rigidus* and *acuminatus* has 9–11 ducts in the outer semicircle and 2 in the central mass (Pierre); while *S. reticulatus* has 13 ducts in the outer semicircle and none in the central mass.

1. Stemonoporus Wightii, *Thw. Enum. Pl. Zeyl.* (1859) 37; *Trimen, Fl. Ceylon*, i. 132.—Vateria ceylanica, *Wight, Ill.* i. 88; *Dyer in Hook. f. Fl. Brit. Ind.* i. 314.—Pl. III. fig. 26.

Calyx imbricate, pubescent outside. Anthers linear, a little broader at base; appendix of connective short, acute. Ovary pubescent; style glabrous, cylindrical, furrowed, longer than ovary. Fruiting-calyx reflexed. Hypocotyl short, lying outside between the auricles of the cotyledons. Outer cotyledon slightly

concave, smooth on the outside, deeply and irregularly furrowed on the inside; inner divided into three or four lobes, and between both cotyledons a ramified fibrous mass, the remains of placenta and dissepiments.

2. Stemonoporus Gardneri, *Thw. in Hook. Journ. Bot.* vi. (1854) 68, t. 2 A; *Trimen, Fl. Ceylon*, i. 133; *Pierre, Fl. For. Cochinch.* fasc. 17, t. 258 H.—Vateria Gardneri, *Thw. Enum. Pl. Zeyl.* 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 314.

Calyx imbricate, puberulous outside. Anthers linear; connective without appendix. Style filiform, longer than ovary. Fruiting-calyx reflexed. Embryo thick, fleshy, lobed.

3. S. acuminatus, *Bedd. Fl. Sylv.* (1870) t. 100; *Pierre, Fl. For. Cochinch.* fasc. 17, t. 258 G; *Trimen, Fl. Ceylon*, i. 133.—Vatica acuminata, *A. DC. in DC. Prodr.* xvi. pars 2 (1864) 622. —Vateria acuminata, *Thw. Enum. Pl. Zeyl.* 403, non *Hayne*. —Vateria jucunda, *Dyer in Hook. f. Fl. Brit. Ind.* i. 314; *Thw. MSS.* fide *Dyer*.—Vesquella acuminata, *Heim, Recherch. Diptérocarp.* 90.—Sunapteopsis jucunda, *Heim, Recherch. Diptérocarp.* 92.

Pedicel as long as calyx, which is slightly imbricate (as correctly shown by Pierre in fig. 1, though represented as valvate in fig. 11), both being hispid with very short stiff hairs. Anthers hispid; connective with a minute blunt appendix. Ovary pubescent; style filiform, glabrous, articulate with ovary; stigma minute. Fruiting-calyx reflexed, as long as fruit; pericarp thick, coriaceous. Seed (unripe) with coriaceous testa and some gelatinous albumen; radicle short; cotyledons thin, flat, much folded and crumpled; base of pericarp on its inner face lined by a thin fleshy cup. Apparently ripe seeds are figured by Pierre. The embryo does not fill up the cavity, and fig. 16 shows the fleshy laciniate cup attached to the base of pericarp on its inner face, which Heim designates as "cupule chalazique."

Upon this species Heim bases two genera, viz. *Vesquella* upon *Vateria acuminata*, Thw., in which he also places *S. oblongifolius*, Thw.; and *Sunapteopsis* upon *Vateria jucunda*, Thw., doubtfully established by him as a genus. The chief character of *Vesquella* is "la présence d'une cupule chalazique ou d'expansions fibreuses chalaziques, absolument anormales, dans le règne végétal tout

entier." This, however, I have also found in *S. canaliculatus*, Thw., and it will doubtless be found in other species of the genus. Another character, upon which Heim relies, is the abundant albumen in the ripe seed. As previously explained, this cannot be accepted as a generic character in the order. *Sunapteopsis*, Heim distinguishes by its long leaves with curved acumen, and by the large unequal segments of the fruiting-calyx, not reflexed, but spreading and lengthened out into long, obovate, acuminate wings. This description seems to refer to another plant altogether. —*Vateria jucunda*, Thw., is certainly a *Stemonoporus*.

4. STEMONOPORUS LANCEOLATUS, *Thw. Enum. Pl. Zeyl.* (1859) 38; *Trimen, Fl. Ceylon*, i. 134.—Vateria lanceolata, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 315.

5. S. AFFINIS, *Thw. in Hook. Journ. Bot.* vi. (1854) 68; *Trimen, Fl. Ceylon*, i. 134.—Vateria affinis, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 314.

Flowers axillary, solitary or two together, 4 bracteoles on lower half of pedicel. In receptacle large cavities filled with white resin. Sepals oblong-lanceolate, imbricate, edges ciliate. Anthers hispid, connective without appendix. Ovary pitted, style filiform, longer than ovary and articulate with it, stigma minute. Embryo bright pink; cotyledons divided into numerous lobes.

6. S. RIGIDUS, *Thw. in Hook. Journ. Bot.* vi. (1854) 69; *Pierre, Fl. For. Cochinch.* fasc. 17, t. 258 J; *Trimen, Fl. Ceylon*, i. 134, t. 15. figg. 6–11.—Vateria rigida, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 315.

Calyx very slightly puberulous, almost glabrous; edges ciliate; connective without appendix. Ovary hairy, ribbed; style articulate with ovary.

7. S. CANALICULATUS, *Thw. Enum. Pl. Zeyl.* (1859) 38; *Trimen, Fl. Ceylon*, i. 135.—Vateria canaliculata, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 315.

Bracteoles at base of pedicel, which, as well as the imbricate calyx, is densely tomentose. Anthers hispid; connective without appendix. Fruiting-calyx spreading. Radicle short, horizontal; cotyledons thick, fleshy, both bifid to base, the cells

filled with starch. At the base of fruit the inner surface of pericarp is lined by a flat membranous cup, the rim of which is divided into 10 linear, laciniate, upright lobes, which penetrate in between the lobes of the cotyledons ("cupule chalazique," *Heim*).

8. Stemonoporus petiolaris, *Thw. Enum. Pl. Zeyl.* (1859) 38; *Trimen, Fl. Ceylon,* 135.—Vateria petiolaris, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 315.

9. S. oblongifolius, *Thw. in Hook. Journ. Bot.* vi. (1854) 68; *Pierre, Fl. For. Cochinch.* fasc. 17, t. 258 I; *Trimen, Fl. Ceylon,* i. 135.—Vateria oblongifolia, *Thw. Enum. Pl. Zeyl.* 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 315.

Sepals imbricate, nearly glabrous. Anthers hispid, with very short hairs. Ovary pubescent; style glabrous, articulate with ovary. Heim makes this a species of *Vesquella*; but there is no reason for separating it from *Stemonoporus*.

10. S. reticulatus, *Thw. Enum. Pl. Zeyl.* (1859) 38; *Trimen, Fl. Ceyl.* i. 136.—Vateria reticulata, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 316.—Künckelia reticulata, *Heim, Recherch. Diptérocarp.* 92.

Tertiary nerves closely reticulate. No bracteoles on pedicels. Sepals slightly imbricate, glabrous, shining. Anthers hispid; connective without appendix. Ovary free, ribbed, conical, pubescent, gradually narrowed into long filiform style, which is not articulate with ovary; stigma minute. Fruit large, ovoid-conical, with 5 deep furrows; pericarp thick. According to Heim a fibrous mass (d'origine chalazique) between the two cotyledons. Heim separates *Künckelia* from *Stemonoporus* chiefly on account of the fruit and the thickness of pericarp. The structure of the flower corresponds entirely with that of *Stemonoporus*.

11. S. nitidus, *Thw. Enum. Pl. Zeyl.* (1859) 39; *Trimen, Fl. Ceylon,* i. 136.—Vateria nitida, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 316.—Doona nitida, *Heim, Recherch. Diptêrocarp.* 72.

Perfectly glabrous.

Between the 5–7 pairs of principal secondary nerves a large number of shorter intermediate nerves, terminating in a system

of reticulate veins, which anastomose with distinct intramarginal veins. Calyx glabrous, nearly valvate. Anthers hispid; no appendix. Ovary free, glabrous; style filiform, articulate with ovary.

12. STEMONOPORUS NERVOSUS, *Trimen, Fl. Ceylon*, i. (1893) 136. —Vateria nervosa, *Thw. in* [*London*] *Journn. Bot.* xxiii. (1885) 206.

13. ? S. MOONII, *Thw. Enum. Pl. Zeyl.* (1859) 39; *Trimen, Fl. Ceylon*, i. 137.—Vateria Moonii, *Thw. Enum. Pl. Zeyl.* (1864) 403; *Dyer in Hook. f. Fl. Brit. Ind.* i. 316.

15. MONOPORANDRA, *Thw.*

Characters of *Stemonoporus*, with the following exceptions:—Tertiary nerves not conspicuous. Stamens 5, episepalous. Ovary generally 2-celled, rarely 3-celled.

1. M. CORDIFOLIA, *Thw. in Hook. Kew Journ. Bot.* vi. (1854) 70; *Pierre, Fl. For. Cochinch.* fasc. 17, t. 258 F; *Trimen, Fl. Ceylon*, i. 137; *Dyer in Hook. f. Fl. Brit. Ind.* i. 317.—Vateria cordifolia, *Thw. Enum. Pl. Zeyl.* 404; *Bedd. Fl. Sylv.* t. 101.

Pedicels nearly as long as calyx; receptacle broadly obconical. Calyx glabrous; petals glabrous. Ovary 2-celled (Herb. Kew) (*Beddome*, 3-celled), slightly puberulous, gradually narrowed into cylindrical fleshy style; stigma unilateral. Fruiting-calyx adpressed to fruit; pericarp thickly coriaceous.

2. M. ELEGANS, *Thw. in Hook. Journ. Bot.* vi. (1854) 69, t. 2 B; *Dyer in Hook. f. Fl. Brit. Ind.* i. 317; *Trimen, Fl. Ceylon*, i. 138.

Pedicels equal to calyx, which is pubescent; petals glabrous. Ovary 2-celled. Fruiting-calyx reflexed. Unripe seeds have thin fleshy cotyledons, emarginate at apex. Cells contain starch.

16. VATERIA, *Linn.*
(Including *Vateriopsis*, Heim.)

Large evergreen trees with coriaceous leaves; stipules narrow, deciduous. Flowers large, pedicellate, in axillary and terminal panicles. Calyx-segments imbricate. Stamens 40–80, the outer smaller. Anthers sessile or on very short filaments, linear; cells

unequal, the outer much longer, dehiscing longitudinally from apex to base. Ovary narrowed into filiform style with minute stigma. Fruit large, supported by small persistent fruiting-calyx, the segments of which are equal. Cotyledons thick, fleshy, unequal.

Numerous (25–60) resin-ducts in the circumference of the pith, which are very unequal in size, the small thin-walled cells lining these ducts filled with a resinous dark-coloured substance. *Vateria Seychellarum* has the same arrangement of the leaf-traces as *Stemonoporus*, that is, the apical trace precedes the two lateral traces. Regarding the other species the examination has not yet been completed. The petiole has an outer semicircle of 10–15 confluent vascular bundles, each with one resin-duct in the pith. The central mass consists of two halfmoon-shaped vascular bundles, with 3–7 large resin-ducts. (Plate I. fig. 18.)

1. Vateria indica, *Linn. Sp. Pl.* 515; *Roxb. Corom. Pl.* iii. t. 288; *Wight, Ill.* i. t. 36; *Dyer in Hook. f. Fl. Brit. Ind.* i. 313.—Vateria malabarica, *Blume, Bedd. Fl. Sylv.* t. 84.

Evergreen forests at the foot of the Western Ghats from Canara to Travancore. Planted largely as an avenue tree; also above the ghats in the western and moister districts of Mysore.

Leaves with 14 pairs of secondary nerves; pedicels longer than calyx-segments. Calyx on the outside stellate-tomentose, pubescent on the inside. Anthers hairy at base, otherwise glabrous; appendix of connective as long as anther (Engler, Nat. Pflanzenfam. iii. 6. Fig. 127 C–E). In some specimens two appendages have occasionally been found. Ovary tomentose; style filiform, glabrous; stigma minute. Fruit 2–2½ in. long, splitting open in three valves; fruiting-calyx small, segments reflexed. Cotyledons filled with fat ("Piney tallow").

2. V. acuminata, *Hayne, Arzn. Gew.* xi. (1830) sub t. 5; *Dyer in Hook. f. Fl. Brit. Ind.* i. 313; *Trimen, Fl. Ceylon*, i. 131; *Heim, Recherch. Diptérocarp.* t. 3.—V. indica, *Gaertn. f. Fruct.* iii. t. 189; *Blume, Mus. Bot.* ii. t. 4.

Moist low country of Ceylon, especially near streams.

Leaves very hairy, with 20 pairs of secondary nerves; pedicel shorter than calyx, in the axil of two large deciduous unequal bracts, the larger of which is exterior, overlapping the smaller.

Pedicels and calyx clothed on the outside with bundles of long hairs, tomentose inside. Anthers hairy all over, hastate at base, the outer cells terminating in long points, which in the outer stamens, however, are short. Ovary conical, densely tomentose, 3-celled, the dissepiments extremely thin; style glabrous, filiform; stigma minute. Fruit ovoid, 3–5 in. long, supported by the small adpressed fruiting-calyx; pericarp $\frac{1}{2}$ inch thick. Embryo almost cylindric; cotyledons thick, fleshy, cells filled with starch and a few oil-drops, unequal, separated by an oblique plane, the larger cylindric with an obliquely truncated top, entire, the smaller bifid. In germinating the pericarp splits into three portions; the (flat) petioles of the cotyledons lengthen out considerably; the cotyledons are raised above the ground, and the fruit is thrown off. The first leaves above the cotyledons are alternate.

3. Vateria Seychellarum, *Dyer in Baker, Fl. Maurit.* (1877) 526, *et in* [*London*] *Journ. Bot.* xvi. (1878) 103.—Vateriopsis Seychellarum, *Heim, Recherch. Diptérocarp.* 94.

Calyx glabrous; connective prolonged into a short point. Ovary glabrous. Fruit globose, $1\frac{1}{2}$ in. diam., supported by the small persistent fruiting-calyx, the segments of which are brittle and break off easily; pericarp leathery; endocarp fibrous. Cotyledons fleshy, base auriculate, and the short thick radicle enclosed by the auricles. The larger cotyledon slightly concave, but not quite embracing the smaller, which is deeply furrowed on the face towards the placenta. Cells filled with starch. In the germinating seed the cotyledons are on long petioles.

Heim bases his genus *Vateriopsis* chiefly upon the glabrous calyx, the short appendage of the anthers, the glabrous ovary, the small fruiting-calyx, and the conformation of the ovary. These characters, however, are not sufficient to justify generic separation in this order.

EXPLANATION OF THE PLATES.

Plate I.

Figs. 1–6. *Dryobalanops lanceolata*, Burck. (All figures magnified 10 times, except 6, which is magnified 17 times: Herb. Regium Berolinense.) The place where sections 1–5 are taken is indicated on fig. 17.

Fig. 1. Base of internode, above insertion of side branch, still attached to the main axis. The main axis has one resin-duct in the pith, and 2 lateral leaf-traces in process of separation from the main cylinder, each with a resin-duct in the pith.

Fig. 2. Higher up in internode. The resin-duct in the pith has bifurcated, the main duct remaining in the centre, while the branch duct is nearer the apex of the pith. The lateral leaf-traces have separated entirely from the central cylinder and are now in the cortex.

Fig. 3. About the middle of internode. The branch duct has bifurcated, one branch being in the apex of the pith, in the apical leaf-trace which is in process of formation, the other branch is destined for the axillary bud. The main duct has also bifurcated, not, however, in the direction of the main axis of the pith, but at right angles to it.

Fig. 4. Below the insertion of the petiole. Two lateral branches of the main duct in the pith are approaching the wood, the medullary rays at this point arranging themselves in a fan-shaped fashion. These lateral ducts are destined to enter the lateral leaf-traces in the next higher internode.

Fig. 5. Petiole formed of the apical and the 2 lateral leaf-traces, the 2 lateral resin-ducts have bifurcated. The lateral resin-ducts intended for the next higher internode are entering the wood.

Fig. 6. Petiole detached from the branch. The central intricate mass of vascular bundles has 5 resin-ducts, 2 of which are on the outside edge of the central mass.

Figs. 7–9. *Hopea cernua*, Teysm. et Binn. (All figures magnified 15 times: Herb. Brandis.)

Fig. 7. Section of an internode 28 mm. long, 8 mm. under insertion of petiole. 3 large resin-ducts in circumference of pith at the 3 corners of a triangle, the apical duct intended for the apical leaf-trace, the 2 lateral for the 2 lateral leaf-traces. A 4th duct on the 3rd concave side destined for the apical leaf-trace of the next higher internode.

Fig. 8. Section, 4 mm. under insertion of petiole. The 2 lateral ducts have bifurcated and the branch ducts have entered the wood.

Fig. 9. Section immediately under insertion of petiole. Two lateral leaf-traces in the bark, each with a resin-duct in pith. The apical duct has subdivided into 5 branches, the 2 lower being destined for the

bud, the 3 upper for the petiole, which thus receives 2 lateral and 3 apical resin-ducts.

Fig. 10. *Shorea obtusa*, Wall. (Magnified 17 times: Alcohol Material, Burma.) Section through the upper half of a leaf-bearing internode. Three leaf-traces in the bark, the apical with 3, each of the two lateral with one resin-duct. The lateral leaf-traces are in course of bending forward, in order to join the apical trace, their xylem and phloëm are no longer directed towards the circumference but towards the apex. Indications of 2 stipular traces, without resin-ducts, below the 2 lateral traces. In the neck of the pith 3 resin-ducts intended for the axillary bud; besides these, in the body of the pith 14 ducts.

Fig. 11. *Dipterocarpus alatus*, Roxb. (Magnified 10 times: Alcohol Material, Burma.) Section through the upper portion of leaf-bearing internode, under insertion of petiole. Three leaf-traces, the 2 lateral in the bark, the apical not yet fully separated from the central cylinder, one resin-duct in each, 8 ducts entering the wood, destined for stipular leaf-traces. Besides these, 22 ducts in pith.

Fig. 12. *Dipterocarpus pilosus*, Roxb. (Magnified 10 times: Herb. Brandis.) Section through leaf-bearing internode, immediately under insertion of petiole. The petiole is in process of formation, the right-hand lateral duct having coalesced with the apical, that on the left-hand being as yet separate. In addition to these there are 6 stipular traces in the bark, each with a resin-duct, the same number of ducts in the wood, destined for 6 more stipular traces. Besides these, in the pith 23 ducts.

Figs. 13–15. *Hopea cernua*, Teysm. et Binn. (All figures magnified 24 times: Herb. Brandis.)

Fig. 13. Petiole at the base. Three distinct vascular bundles, two lateral and one on the underside of the petiole, each with one resin-duct in the pith. A central four-sided ring of xylem and phloëm, enclosing a semicircular vascular bundle.

Fig. 14. Petiole near the top, below insertion of blade. The 2 lateral ducts have bifurcated, the central mass of vascular bundles has changed its shape.

Fig. 15. Transverse section through midrib near base of leaf. The 3 vascular bundles have united and form an undulating semicircle with 5 resin-ducts. The central body consists of one half-moon shaped and 2 elongated masses of xylem and phloëm.

Fig. 16. *Hopea odorata*, Roxb. (Magnified 17 times: Alcohol Material, Calcutta.) Petiole below insertion of blade. Nine vascular bundles, each with a resin-duct, forming a continuous semicircle on the underside of the petiole. The semicircle is closed at the top by a straight bar

of xylem and phloëm, not very distinctly shown in the figure. The central body mainly consists of one large and one small half-moon-shaped mass of xylem and phloëm, without resin-ducts.

Fig. 17. Internode of *Dryobalanops lanceolata*, Burck, showing lateral leaf-traces as raised lines. The places where sections 1–5 were taken are indicated.

Fig. 18. *Vateria acuminata*, Hayne. (Magnified 10 times: Alcohol Material, Ceylon.) Midrib at the base of blade. Outer semicircle of 11 vascular bundles, each with a resin-duct, closed on the upperside by a straight bar of xylem and phloëm. A continuous ring of bast-fibres encloses the whole. The central mass consists of two half-moon-shaped vascular bundles, xylem above, phloëm below, each with 3 resin-ducts.

Plate II.

Figs. 1, 2. *Hopea Helferi* (*Vatica Helferi*, Dyer), stamen and ovary cut open.

3, 4. *H. oblongifolia*, Dyer, ovule, ovary cut open.

5, 6. *H. discolor*, Thw., ovary cut open, part of inflorescence.

7. *H. parviflora*, Bedd., ovary.

8, 9. *H. cernua*, Teysm. et Binn., stamen and ovary cut open.

10. *H. Pierrei*, Hance, ovary.

11, 12. *Parashorea stellata*, Kurz, anther and ovary.

13, 14. *Shorea Thiseltoni*, King.—13. Stamens, one of the 5 inner episepalous longer stamens, with 2 of the outer circle; the third outer stamen, which stands opposite to the longer stamen of the inner circle, has been omitted. 14. Ovary cut open.

15, 16. *S. vulgaris*, Pierre, stamen, ovary.

17, 18. *S. Pinanga*, Scheff., stamen, ovary cut open.

19, 20. *S. floribunda*, Kurz, stamen, ovary cut open.

21, 30. *S. inappendiculata*, Burck, ovary cut open, stamen.

22, 23. *Balanocarpus zeylanicus*, Trim., stamen, ovary cut open.

24. *B. Curtisii*, King, ovary cut open.

25, 26. *B. coriaceus*, Brandis (*Richetia coriacea*, Heim).—25. Embryo, showing the long radicle, to which are attached, near the base of seed, the two cotyledons, each divided into two fleshy lobes: *r.c.*, the lobes of the radicular; *p.c.*, those of the placentar cotyledon. 26. Lower portion of loose membranous testa, enveloping placenta (*p*) in a fold (not clearly) indicated on the right-hand side. Testa and placenta intrude between the two lobes of the placentary cotyledon.

27. *B. Hemsleyanus*, King, ovary cut open.

28. *Anisoptera thurifera*, Blume, ovary cut open.

29. *A. grandiflora*, sp. nova, stamen. (Ovary: see Plate III. fig. 1.)

30. See above, under *Shorea*.

Plate III.

Fig. 1. *Anisoptera grandiflora*, sp. nova, ovary.

2–4. *Vatica lanceæfolia*, Blume, stamen, calyx, inflorescence with 2 pseudo-terminal flowers.

5. *V. Ridleyana*, sp. nova, one of the 5 interior stamens, hinder side.

6. *V. celebensis*, sp. nova, one of the exterior stamens.

7, 8. *V. Griffithii*, n. sp., stamen, ovary cut open.

9. *V. Scortechinii* (*Retinodendron Scortechinii*, King), ovary cut open.

10. *V. Kunstleri*, King, stamen.

11. *V. oblongifolia*, Hook f., top of style with stigma.

12–14. *V. pedicellata*, sp. nova: (12) one of the interior, (13) one of the exterior stamens; (14) ovary with calyx.

15–17. *V. Dyeri* (*Synaptea Dyeri*, Pierre): (15) anther after dehiscence; (16) horizontal section of same; (17) ovary cut open, hairs on free portion omitted.

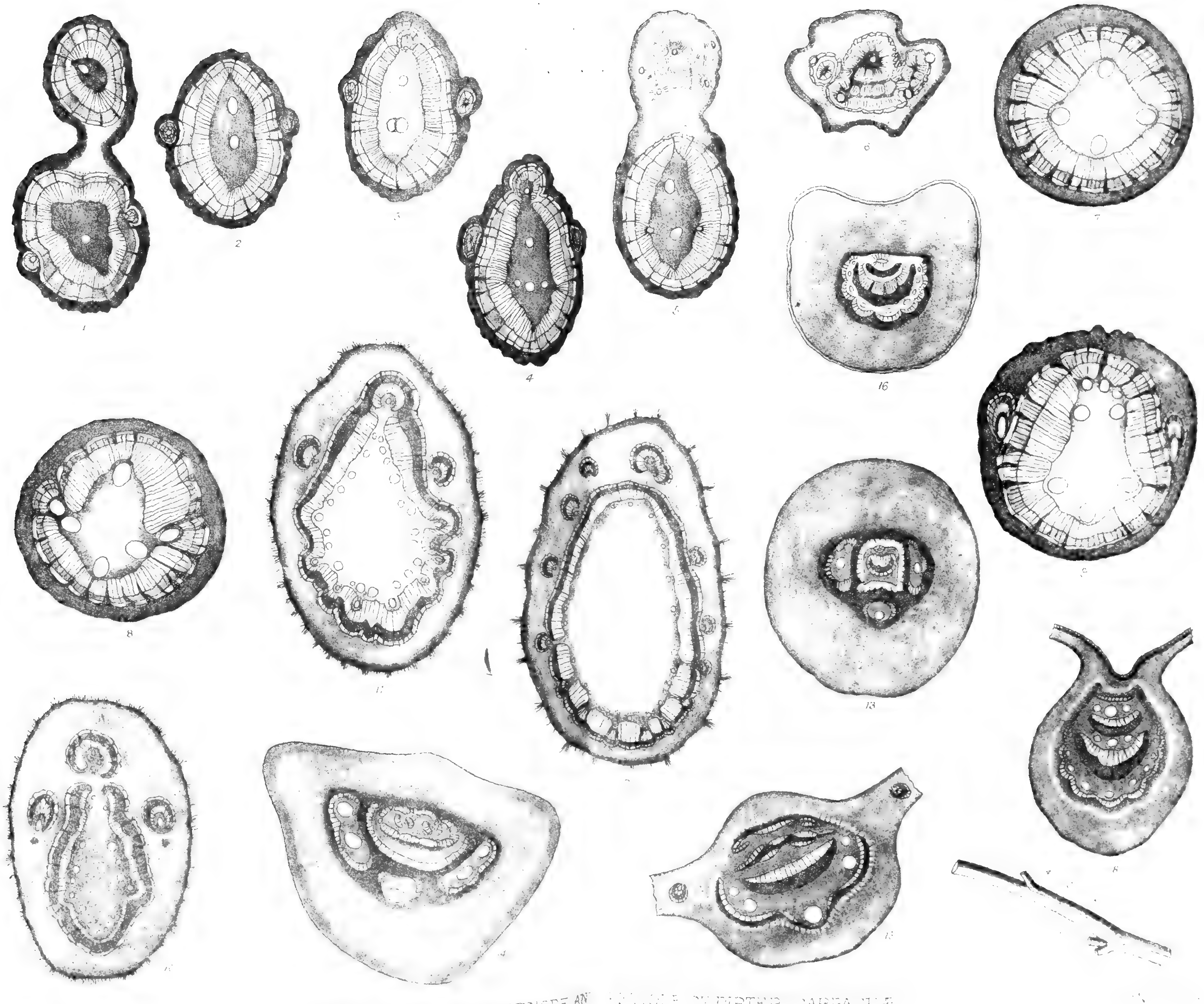
18, 19. *V. perakensis*, King: (18) inflorescence with pseudoterminal flower; (19) ovary cut open.

20, 21. *V. Bureavi*, Heim, stamen, ovary cut open.

22–24. *Cotylelobium flavum*, Pierre: stamens, (22) Singapore, (23) Borneo; (24) ovary cut open.

25. *Pachynocarpus umbonatus*, Hook. f., inflorescence with a pseudo-terminal flower.

26. *Stemonoporus Wightii*, Thw., anther after dehiscence, hairs not shown.



STRUCTURE OF INTERNODE AN[illegible] OF DIPTERIS [illegible]

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STRUCTURE OF THE

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STRUCTURE OF DIPTEROCARPACEÆ

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NOTICE.

Vols. XXVI. & XXXI. are in course of simultaneous issue to expedite the publication of papers, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–213. (The present Part.)

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The next Meeting of the Society will be held on November 7th, when the Chair will be taken at 8 P.M.

DECEMBER 17. Price 4s.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

Contributions to the Knowledge of Monocotyledonous Saprophytes. By PERCY GROOM, M.A., F.L.S.

[Read 20th December, 1894.]

(PLATES IV.–VI.)

SAPROPHYTES may be defined as plants which are dependent for their existence on the presence in the substratum of decaying organic matter. Like parasites, they may be divided into those which possess chlorophyll (hemisaprophytes) and those which have none (holosaprophytes).

So far, very few experiments have been conducted on hemisaprophytes; and we are dependent for our assumption that such plants exist upon the fact that in some plants which are always found growing in humous substrata the amount of chlorophyll is small (species of *Corallorhiza*?), or that the allies are holosaprophytic, or that attempts to cultivate the plants in the absence of humus have failed (Cupuliferæ), or, finally, that peculiarities of structure characteristic of holosaprophytes appear in certain forms always found in situations rich in humus (absence of root-hairs in certain terrestrial orchids and gentians). Thus, our acquaintance with hemisaprophytes is largely speculative. And the present remarks refer almost entirely to holosaprophytes, or at least to plants with scarce a trace of chlorophyll.

Holosaprophytes amongst Monocotyledons are found only in the Orchidaceæ, Burmanniaceæ, and Triuridaceæ *. They are all plants characterized by possessing leaves in the form of small scales, and a simple undifferentiated embryo.

Hitherto only a few of these have been investigated as regards the histology of their vegetative organs. Schacht and Irmisch made some observations on European orchidaceous holosaprophytes (*Epipogum*, *Corallorhiza*, *Neottia*) (1); Prillieux and Drude on *Neottia* (2); Reinke on *Corallorhiza* and *Epipogum* (3); Johow on various Orchidaceæ, Burmanniaceæ, Triuridaceæ, and Gentianaceæ (4); Poulsen on *Triuris* and *Sciaphila* (5, 6).

Johow gives a complete summary of his own extensive work

* I think it possible that *Petrosavia* is a saprophyte, not a root-parasite. In this case the Liliaceæ must be added to the list.

and that of others on holosaprophytes belonging to Monocotyledons and to Dicotyledons. This summary may be briefly given here.

1. There is a tendency for the root-system to diminish greatly in surface till roots may be entirely absent. But exceptions exist in all the monocotyledonous families; for long fibrous roots may occur, or a close system of many short roots.

2. The root-system, or the rhizome replacing it, often assumes a coral-like or stellate form.

3. No fully-developed root-hairs occur in any saprophyte with the exception of *Sciaphila Schwackeana*.

But hairs functioning as root-hairs are well developed on the rhizomes of *Corallorhiza innata*, *Epipogum aphyllum*, and *Dictyostegia orobanchoides*.

4. As regards the outer layer which persists over the root, no general rule prevails.

5. The cortex is greatly developed in the roots of all saprophytes, and is formed of cells in regular circles or radii.

6. Concerning the endodermis, no general rule prevails.

7. Pericycle is a distinct layer in monocotyledonous roots; but not so in the Dicotyledons.

8. As regards the central cylinder: in all holosaprophytes, with the exception of *Neottia nidus avis* and *Sciaphila caudata*, deviations from the normal type occur. The modifications consist either in reduction in the vessels, or in a changed grouping in the xylem and phloëm, or in incomplete differentiation of the procambium.

9. Mycorhiza is present in all holosaprophytes excepting *Wullschlægelia*.

10. The structural modifications in the shoot are not nearly so striking as those in the root.

11. The epidermis of holosaprophytes has no stomata. But in *Epipogum aphyllus* the subterranean parts have stomata.

In the cortex of the floral axis colouring-matters are usually present; the intercellular spaces are small because of the absence of chlorophyll.

The mechanical system of the floral axis is in all cases restricted to a general sheath of sclerenchyma, on the inner side of which the vascular bundles lie.

The vascular bundles in the rhizome and floral axis are usually

abnormal in structure. The peculiarities arise from the changed grouping of their constituents or from their reduction.

As will be seen later on, some of these generalizations remain no longer true.

Special Work on Orchidaceous Holosaprophytes.

History.—A brief summary of our knowledge concerning the histology of orchidaceous saprophytes may be formed by a reference to the accounts of *Corallorhiza*, *Epipogum*, *Neottia*, *Wullschlægelia*, and *Pogoniopsis*.

In *Corallorhiza innata* and *Epipogum aphyllum* the plant consists of a subterranean rhizome and a flowering axis. (There may be a small remnant of a root—" Keimaxe " ?)

Corallorhiza innata is said to possess chlorophyll in small quantity. The *rhizome* has small scale-leaves; and on it are small conical papillæ which bear hairs functioning as root-hairs. An epidermis covers a cortex which is differentiated, according to Reinke, into three portions:—

(1) An outer portion composed of cells containing hyphæ and starch.

(2) An intermediate portion the cells of which contain yellow slime (mycelial masses, P.G.) but no starch.

(3) An inner portion again containing starch. Here and there radial strands of starch-containing cells connect the inner and outer portions of the cortex. Starch disappears from the rhizome as the inflorescence-axis shoots up, but reappears as the fruit is forming.

An endodermis surrounds the central stele of the rhizome. Within this Reinke describes two groups of spiral vessels and 3–5 groups of phloëm on the same or on different radii. The phloëm, he says, is composed of narrow prosenchymatous cells with somewhat thickened walls which are separated from the endodermis and from the wood-vessels by cells with delicate walls.

A single vascular bundle runs from each scale on the rhizome, and consists of wood-vessels surrounded by phloëm-cells.

In the *inflorescence-axis* a general sclerenchyma-sheath includes a single circle of vascular bundles. Each bundle is composed of phloëm-cells which surround and separate one to two groups of wood-vessels (*Reinke*).

In Epipogum aphyllum the scales on the rhizome are more

reduced than those of *Corallorhiza*, and there are no leaf-trace bundles. The scales are visible only at the growing point (*Reinke*). Histologically the cortex of the *rhizome* agrees with that of *Corallorhiza*. But Reinke says that in the central cylinder there is no distinction into phloëm and xylem; the vascular tissue, he states, is represented by a homogeneous mass of prosenchymatous cambiform cells.

In the *inflorescence-axis* there are several circles of vascular bundles in which phloëm and xylem are distinct.

De Bary states that stomata occur in the rhizome of *Epipogum aphyllum.*

Drude, in 1873, issued a monograph on NEOTTIA NIDUS-AVIS, adding to the observations of Schacht and Prillieux on the morphology of this plant. He also made a number of observations on the assimilation of carbonic acid by the plant, under the belief that *Neottia* contained chlorophyll. He came to a conclusion that *Neottia* does assimilate carbon dioxide.

Histology of the Inflorescence-axis.—Outside is epidermis with no stomata. Then follow several layers of elongated cortical parenchyma. The ring of vascular bundles is embedded in a general sheath of sclerenchyma-fibres. Some of these bundles have xylem radially exterior, as well as interior, to the phloëm. The xylem consists solely of vessels.

The scale-leaves have no stomata, and several vascular bundles traverse them.

Histology of the Rhizome.—The rhizome structurally agrees in the main with the inflorescence-axis. But vascular bundles going to the roots traverse the cortex; and several layers of cells near the epidermis contain a brown substance (mycelial masses).

Within the epidermis lie 2–3 layers of cells similar to it, then come 1–2 layers of larger cells containing the brown substance. The rest of the cortex is rich in starch. A general sheath of sclerenchyma, two circles of vascular bundles (smaller than in the stem), and ground-tissue which in the centre forms a pith, complete the structure.

Histology of Roots.—A root-cap is present; within the epidermis succeed two layers similar to it; then two layers of larger parenchyma with brown substance. And within these lie layers of parenchyma which contain starch, and gradually diminish in size till the innermost form a sheath around the "central vascular bundle" (*sic*).

In the "central bundle" (central cylinder) the masses of xylem form numerous isolated groups which sometimes fuse into long masses. The centre is formed of parenchyma rich in starch. Phloëm devoid of starch forms a peripheral tissue of elements with narrow lumina.

Johow describes the roots of *Neottia Nidus-avis* as typical in structure and triarch. According to him, the central cylinder commences with an unthickened endodermis, within which lies a pericycle. He says nothing with reference to the minute histology of the phloëm, but figures the xylem without giving details. No exodermis is present. In Johow's figures one can recognize three outermost layers of cortex without mycelia; then 2–3 layers with mycelia; and within six layers with no mycelia.

WULLSCHLÆGELIA, Johow says, possesses two sorts of *roots*:—(1) Thin filamentous roots of normal pentarch structure with an exodermis and a transitory epidermis. (2) Fleshy roots with flagelliform appendages in which transitions from a pentarch to a triarch central cylinder are seen. The *stem* of *Wullschlægelia* has normal vascular bundles.

Of POGONIOPSIS, Johow remarks that the central cylinder in the *root* is reduced. In the centre are two or three wide wood-vessels. The pericycle is invested by a weakly thickened irregular endodermis. The cortex consists of 3–4 layers of cells. There is no exodermis. The epidermis persists, and some of its cells form short blunt root-hairs. In the *inflorescence-axis* a ring of vascular bundles lies against the general sclerenchyma-sheath. In the vascular bundles phloëm and xylem are differentiated.

Thus, in Johow's work the important question as to the minute histology of the vascular bundles is left all but untouched. In particular, no details concerning the composition of the phloëm are given.

Present Observations.

GALEOLA JAVANICA, *Benth. & Hook. f.* (Cyrtosia javanica, *Blume*).

This plant was first described by Blume under the name of *Cyrtosia javanica.* It was not included under the genus *Galeola*, because its fruits are succulent, and are said not to dehisce. But Sir Joseph Hooker points out that *Galeola Lindleyana* (*Cyrtosia Lindleyana*, Hook. f. & Thoms.) has fleshy fruits which exhibit no signs of dehiscence till old and dry; and even then the valves

frequently do not separate wholly. Hence no sharp distinction between species of *Galeola* with dry dehiscent fruits and species with succulent fruits can be maintained.

Blume's original description may be here given in so far as it refers to the vegetative characters :—

" *Habit.* In Javâ occidentali, in saltibus altiorum montium, veluti in monte Salak, supra agros coffeâ consitos elevatiores, ubi variis anni temporibus hanc plantam florentem fructibusque onustam indagavi.

"*Descr. Planta* carnosula, *Orobanchis* nostris habitu simillima.

" *Radix* fibris creberrimis crassis carnosis cylindricis aut claviformibus in fasciculum congestis inæqualis longitudinis constans.

" *Caules* plerumque ex eadem radice, spithamei, arrecti, simplicissimi aut in ramos aliquot alternos erecto-patentes divisi, ex tereti subangulati, rubicundi, ætate purpurascentes, inferne glabri ac nitidi, apice papilloso-scabridi. Pro foliis squamæ subcarnosæ, alternæ, ovatæ, acutæ, concavæ, ejusdem coloris ac caules, sed quæ ad basim eorum sunt, majores magisque approximatæ, in fuscum vergentes."

This description may be supplemented by a few explanatory remarks.

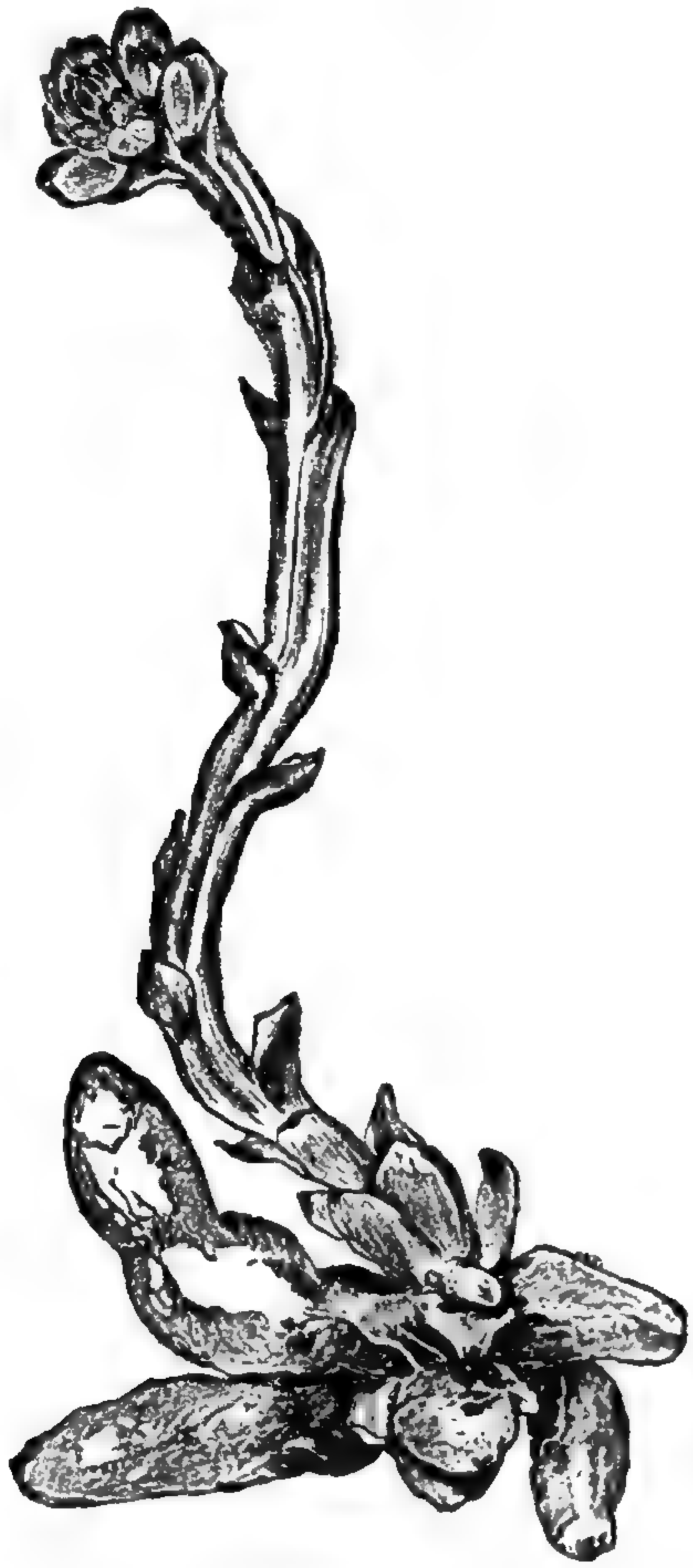
The subterranean part of the plant is not simply a massive root-system, but is made up of a short irregular rhizome on which are densely set the large, club-shaped fleshy roots, scales and scale-bearing buds of varying size.

The stems to which Blume alludes are the inflorescence-axes, which alone are visible above ground. The scales on them are decurrent (woodcut 1).

My material consisted of one plant with an inflorescence-axis, and bearing three large succulent fruits. And all the observations relate to this plant. In addition, I had another plant which was much smaller and younger. In this plant (fig. 1) there was also one inflorescence-axis surmounted by a number of floral buds. In external morphology and histologically it agreed with *Galeola javanica*, and its flower-buds were those of an orchid. It undoubtedly belonged to the same genus ; but as it possibly might be another species, I shall throughout the paper describe it as specimen B, and particularly state when the observations refer to it. In addition, I had two roots of a mature plant collected by Professor Stahl.

Sir Joseph Hooker made some anatomical observations on *Cyrtosia Lindleyana* (Hook. f. & Thoms.), which grows in temperate woods at a height of 5000–7000 feet on the Himalayas and Khasia mountains. He says that the tissues abound in

Fig. 1.



Young plant of *Galeola javanica.*

a viscid fluid, and are formed of a loose cellular tissue full of oblong and quadrate cells containing raphides, and traversed by stout woody bundles. The latter are composed of spirally-marked tubes, long superimposed cells with dotted walls, very broad tracheæ, and thick-walled tubes with their walls perforated by pores surrounded by disks (bordered pits, P.G.) much resembling the woody tissue of Coniferæ.

He further mentions the multicellular hairs of the ovary, and says that along the back of each placenta is a dense mass of white conducting (?) tissue formed of delicate white transparent mucilage-tubes.

Thus Sir Joseph Hooker showed that the xylem elements of the

vascular bundles are well defined, that mucilage and raphides are abundant, and that in the placentæ there is a large development of mucilage-producing tissue.

The subterranean part of the plant consists of a large mass of succulent roots attached to a small irregular rhizome (fig. 1) The whole mass measures 5 inches in length, the longest root being 4 inches long.

Roots.

The roots are all succulent and unbranched, and they vary in length. Each root at its point of attachment is about a quarter of an inch in thickness; travelling towards its apex, it rapidly increases in thickness till its diameter is about half an inch; the root maintains this thickness till it ends bluntly at its apex.

Histology of the Root.

In their minute structure the roots vary considerably in their different parts.

Describing first the mature structure of the root:—

The first characteristic of the root is that it is not covered by any definite layer of cells. In some regions a piliferous layer is represented by a larger or smaller patch of relatively not thin-walled cells united without intercellular spaces. They contain dense coiled masses of hyphæ (mycorhizal), cytoplasm, and well-defined nuclei. A few of these cells grow out into short, broad, thick-walled cuticularized root-hairs. The root-hairs tend to lie flat on the surface of the root in place of protruding freely. Hyphæ occur in the root-hairs. But over the larger part of the root there is no trace of this piliferous layer, the superficial layer being irregular, and formed of cells with very thick, pitted, suberized walls (Pl. IV. fig. 4). These cells are elongated in the direction of the root-axis. Thus, the surface is uneven, and in many places there is clearly no regular layer of cells; even mucilage-sacs may reach the surface. But whatever layer of the cortex forms the superficial cells, the cells assume the same character as regards the thickness and suberization of their walls (Pl. IV. fig. 4), always excepting the primary piliferous layer. Mycorhizal hyphæ may be seen running through these cells from the outside to the cells lying within. Even when the piliferous layer persists, the subjacent layer has thick suberized walls; but there is no definite regular exodermis.

Protruding into the cavity of these thick-walled cells are frequently certain peculiar papillæ which are attached to the thick wall (Pl. IV. fig. 4). They are especially seen on the thick tangential walls, pointing radially into the cavity of the thick-walled cells or of the subjacent cells, but everywhere are only on thick walls. They look like processes of the cell-wall, do not swell in sulphuric acid, but in general answer the tests for cuticle. Their nature will be discussed later in the paper.

Within, there typically succeed three peculiar layers of the cortex. These are sharply marked off from the cells lying more deeply by their shape, size, and contents. As these peculiar cortical layers are met with in other saprophytic orchids, I propose to allude to them collectively under the name of *exocortex* (Pl. IV. fig. 4). The cells comprising the three layers of the exocortex have thin cellulose walls; they are flattened radially, elongated tangentially and in the direction of the root-axis. They contain living protoplasm, little or no starch, and many of them have mycelia in which the hyphæ are distinct from one another. With regard to the mycelia, many of the cells of the outer two layers have no hyphæ, the latter often passing directly radially inwards to the third (innermost) layer, the cells of which usually contain mycorhizal hyphæ with thick glistening walls. The hyphæ in the two outer layers have, as a rule, thin walls.

Occasionally a curious distribution of starch may be seen in the exocortex. In certain spots hyphæ can be seen penetrating the superficial cells and passing radially inwards through the exocortex, scarcely spreading at all tangentially till the third layer is reached. In these cells traversed by hyphæ no starch is visible. But in the cells which have no mycelia starch is found abundantly. These latter cells do not absorb from the exterior, as a thick-walled layer is invariably external to them, and no hyphæ penetrate the thick walls to permit inward passages of liquids. Thus these starch-containing cells merely receive food supplied by the cells containing hyphæ.

In parts of the root some of the cells immediately beneath the external layer have thick cuticularized walls, and they form patches of thick-walled tissue lying in the exocortical region. In such cells peg-like papillæ, identical with those described, are frequently found protruding from the walls. In favourable sections it may be seen that the pegs protrude into the cells only

from those walls which belong also to cells containing hyphæ, and these pegs are directed away from these latter cells. In fact, the pegs are much modified and thickened walls of arrested hyphæ. The following facts show that this interpretation is correct:—(1) Often an axial canal can be seen running up the centre of the peg and ending blindly; this canal is continuous with a pit traversing the cell-wall. (2) In all cases which observation can establish the occurrence of the pegs coincides with the distribution of mycorhizal hyphæ in the region of cells with thick modified walls. Thus, in a root-apex frequently mycorhizal hyphæ, inside and outside the root, can be seen only on one side of the root; the peculiar pegs occur only in connexion with the thick-walled superficial cells of the same side. In cells not lying on the surface the pegs occur only on walls of cells adjoining other cells which have mycorhizal hyphæ. This latter statement holds not only for cells in exocortical regions, but for certain cortical cells of root and rhizome lying much further inwards, and having thick lignified and pitted walls. (3) In these last-mentioned cells transition-stages to hyphæ may be seen. (4) Often the pegs are bluntly branched. (5) In aerial parts smaller but similar pegs occur in connexion with thick-walled epidermal cells; and in connexion with sclerenchyma-cells where wounds have permitted the ingress of hyphæ. (6) In the apex of the root the thick walls of the superficial cells turn yellow with caustic potash; but the pegs remain white. Thus, the pegs are the ends of hyphæ the growth of which has been arrested, whilst the wall has thickened. I suppose the arrested growth is occasioned by the rapid deposit by the cell of layers of cell-wall on to the hyphal wall. For I could not succeed in ever tracing the stratification of the pegs through the cell-wall. The stratification, on the other hand, appeared continuous with that of the cell-wall. At first it suggested itself that these pegs might belong to a fungus which was not symbiotic, but which would injure the roots. This view is negatived by the fact that deep in the cortex the mycorhizal hyphæ can be traced directly into the pegs. In addition, the pegs occurred in all three plants which were examined. Outside the root, the hyphæ originally continuous with the pegs die off; so the pegs cannot be regarded as anchoring organs or as functioning as haustoria (except possibly for a very short and evanescent period).

Amongst the exocortical cells run a few isolated longitudinal rows of raphide-mucilage cells.

The layers of cortex lying within the exocortex are sharply marked off from the latter without any intermediate stages. They are larger, and are not radially flattened; but in transverse section are isodiametral. At the base of the root there are about fourteen layers of cortical cells lying between the exocortex and the endodermis. Where the root has attained its maximum thickness, there are about double the number of these layers. There is, however, a differentiation in these cortical cells. The outer cells comprising two-thirds of this part of the cortex are large parenchymatous cells elongated in the direction of the axis, and with slight collenchymatous thickenings around the small intercellular spaces. They differ from the cells comprising the inner third in their contents, and sometimes fundamentally are distinguished by their form. But these two regions of the cortex are not so sharply marked off one from another as they are from the exocortex. The great distinction between the two is that the outer portion—the *mediocortex*—usually contains mycelial masses, whilst the inner part has no mycelia, and may be termed the *endocortex*. In the roots of this plant the *mediocortex* is further characterized by being extremely rich in starch, even where no mycelia are present; the endocortex, on the other hand, has much less starch, sometimes none.

In the mediocortex the mycorhiza consists of yellow glistening masses not distinguishable into separate hyphæ (Pl. IV. fig. 4). These masses are connected from cell to cell by their strands, which are modified hyphæ. Cytoplasm lines the walls and coats the mycelial masses, and is packed with countless minute starch-grains. A large nucleus is visible in each cell. The mycelia are seen to best advantage by staining with Grenacher's hæmatoxylin, washing with increasing strengths of alcohol, clearing with oil of cloves, and mounting in Canada balsam. The masses and their hyphal strands remain stained, whereas the cytoplasm is completely decolorized, though the nucleus is deeply coloured.

Interspersed amongst these cells are longitudinal rows of raphide-mucilage cells. With iodine the mucilage stains beautifully in tints varying from pink to crimson-violet, according to the strength of the solution employed. Each mature cell (Pl. IV. fig. 4) shows a group of raphides embedded in a deeply stained central

mass of mucilage. Around this is a vacuole across which stretch a few threads of mucilage connecting the central mass with a much larger peripheral sponge-work of mucilage*. The nucleus lies crushed flat against the wall.

The endocortex varies considerably in structure. Apart from the distinctions already mentioned, it differs from the mediocortex in that the raphide-mucilage cells are smaller in size and fewer in number. At the base of the root the whole of the endocortex is converted into cells having very thick lignified walls with numerous simple pits. These cells preserve their nuclei and protoplasmic contents, and may contain starch. This change even invades the mediocortex, so that one to two of its innermost layers have these thick lignified walls, but contain mycelial masses. Thus a complete section of such a root would display:—(1) Piliferous layer. (2) 3–4 layers of exocortex. (3) Nine layers comprising the mediocortex, of which the two innermost have thick lignified walls. (4) Five layers constituting the lignified endocortex. (5) Endodermis and central cylinder.

Tracing such a root towards the apex, the number of lignified layers diminishes, the outer ones first losing their thick walls, till there is only one layer immediately outside the endodermis which is lignified. This single layer is notably interrupted opposite the xylem-bundles by thin-walled cells, which obviously function as passage-cells and lie immediately outside the slightly protruding passage-cells of the endodermis (Pl. IV. fig. 5). This last layer loses its thick walls. The object of this large production of mechanical cells will be discussed later.

The *endodermis* is a single layer consisting of cells with thin suberized walls (fig. 5).

The *pericambium* (fig. 5) forms a single complete layer, and in some spots it is two cells thick. Each cell is brick-shaped and protoplasmic.

There are numerous (20–28) alternating bundles of xylem and phloëm.

The *xylem* is made up of tracheïdes and parenchyma (Pl. IV. fig. 5). The tracheïdes increase in calibre from without inwards, and have transverse-bordered pits, so that the thickening varies from pitted to scalariform and reticulate. Each xylem-bundle

* It must be recollected that the observations were made on material fixed with ordinary methylated spirits, so it is impossible to say how far this resembles the original structure.

is surrounded by a sheath of narrow parenchyma-cells longitudinally elongated. Often those in the inner side are lignified and stretch across from bundle to bundle within the phloëm; thus a complete lignified ring is formed. Frequently, too, the parenchyma-cells at the sides or even between the tracheïdes are lignified, but heavily pitted. The tracheïdes are really few in number, and in most parts of the root the lignified portion, seen in the stele to form a connected mass, is mainly made up of elongated, heavily pitted parenchyma-cells. These in transverse section are easily distinguished by their protoplasmic contents. As the terminal walls are oblique or transverse, they might equally well be termed fibres.

Phloëm is mainly constituted of elongated thin-walled parenchyma-cells. A few narrow sieve-tubes occur and have terminal sieve-plates. The sieve-tubes communicate by lateral pits with some of the more slender parenchyma-cells, which must functionally represent companion-cells. The sieve-tubes may be recognized by their thicker glistening walls. Thus in the phloëm there is, compared with a normal plant, an increase in the parenchyma and a dwindling of the sieve-tubes.

The *pith* is considerable in size, and typically consists of elongated parenchyma-cells with cellulose-walls and delicate collenchymatous thickenings round the distinct intercellular spaces. A few longitudinal rows of raphide-mucilage cells occur. But at the base of the root the pith is smaller, and all its cells possess thick lignified walls. Travelling towards the apex of the root, this lignification diminishes *pari passu* with the lessening of the number of lignified layers outside the endodermis. But it is the central cells of the pith which first lose their thick walls, and the peripheral layers which preserve them longest. The number of raphide-mucilage cells diminishes in the pith as the lignification increases.

Thus, at its point of attachment the root is more slender, but there is a large production of mechanical cells which are connected with similar cells in the rhizome. Examining the subterranean parts, one sees that some roots arise close together and exert considerable pressure on each other, so that there is a marked flattening on the side of the younger root. If there were no mechanical cells at the slenderest part of the root, the pressure of the contiguous parts would cause bending and ultimately rupture. Hence the advantages of a production of mechanical tissue at this point. I cannot say whether this production is

spontaneous or whether it be the result of a stimulus conveyed by contact (compare the production of mechanical cells in climbing organs).

Structure of the Apex of the Root.

A root-cap covers the tip. It is made up of comparatively few layers of cells, the outermost having thick cuticularized walls. In some roots mucilaginous degeneration of large numbers of the meristematic cells of the root-cap sets in. The mucilage shows the same spongy structure and staining properties exhibited in the raphide-mucilage cells. The meristematic cells naturally are devoid of starch, but those immediately around the masses of mucilage are packed with starch. Travelling out from the mucilaginous mass, the amount of starch in the cells gradually diminishes till it occurs only on those halves of the cells which are nearer the mucilage, and beyond this point no starch occurs. Thus the process of degeneration into mucilage commences by a pathological accumulation of starch on one side of the cell; gradually this abnormal production of starch takes place throughout the whole cell, till it becomes packed with starch. My material did not permit me to trace the stages between this stage and the first one of mucilaginous degeneration of the cells.

As might be anticipated in such massive succulent roots, it is impossible to see any sharp distinction into histogens. However, the very early differentiation of the exocortex is easily seen, as is the precocious development of the raphide-mucilage sacs. Recollecting that the piliferous layer of a monocotyledonous root is typically the external cortical layer, and that a multilamellar velamen is merely this layer divided by periclinal walls, it can be seen that the exocortex is genetically very similar to the velamen. Its origin, position, and contents would seem to indicate that the endocortex is, like the velamen, primarily a region of the cortex specially calculated to absorb and pass on absorbed liquids to the subjacent cells. And this hypothesis is further confirmed by the occurrence of a similar layer in rhizomes which perform the absorptive functions of roots.

The *roots of specimen B* are much smaller and more slender than those of the larger specimen. Woodcut 1 represents the plant in its natural size.

The distinction between the roots of the two plants merely consists in a difference in the number of cells. In addition, near

the base of the roots of B the starch is collected in the endocortex rather than in the mediocortex, which has but little in its outer layer. And corresponding to this increased amount of starch in the endocortex, the raphide-mucilage sacs are more abundant in the endocortex than in the mediocortex.

Origin of the Roots.

In *Galeola* the roots are unbranched ; new roots arise at the flowering axes. I cannot certainly state how the root arises; but, from the single very young one which I saw, it seems pretty certain that the roots arise in the inflorescence-axis, not from the pericycle, but by differentiation in the immature cortex; the epidermis of the axis does not appear to aid in forming the root.

If this be correct, the mode of origin is strikingly like that in *Neottia.*

Summary of Results concerning the Root.

1. The *piliferous layer* produces but few short hairs. In most places it peels off. There is no definite regular exodermis, but everywhere, beneath the piliferous layer or exposed to the surface, the root-cortex is coated by cells with at least the external walls thick and suberized, even at the growing point. These cells are admirably calculated to prevent loss of water, but it appears that absorption of solutions can only take place at spots perforated by the mycorhizal hyphæ.

2. Beneath succeed about 3 layers (3–5) of thin-walled cells, constituting *exocortex* with active mycelia in most of the cells. Starch is present only in cells devoid of mycelia. The hyphæ can be traced to the outside of the root.

3. So far as can be judged by the structure of the superficial layer and exocortex, the older parts of the roots are just as capable of absorbing solutions as are the young parts.

4. Within, succeed layers of cortex capable of being occupied by mycelial masses (*mediocortex*), and rich in starch and in raphide-mucilage sacs.

5. These layers are succeeded by the *endocortex*, which is incapable of entertaining the mycelia and is poorer in starch.

6. The *endodermis* has thin suberized walls. When a single layer of mechanical cells lies outside it, this layer has passage-cells outside the passage-cells of the endodermis, *i. e.* opposite the bundles of xylem.

7. There is a *pericambium.*

8. The *xylem* is well differentiated, but has no vessels.

9. The *phloëm* is marked by a large increase in the parenchymatous cells and a dwindling of the sieve-tubes.

10. A *pith* is present and stores up starch and has a few raphide-mucilage sacs.

11. In the cortex there is sometimes a centrifugal production of mechanical cells, whilst in the pith there is simultaneously a centripetal manufacture of mechanical cells.

12. The distribution of the raphide-mucilage sacs appears to correspond with that of starch. Usually they are present in largest quantities in the mediocortex, and to a less extent in the endocortex. But where (specimen B) the distribution of starch is reversed, so is that of the raphide-mucilage sacs. In the root-cap mucilaginous degeneration is heralded by an abnormal accumulation of starch. On the other hand, when cells become lignified, the mucilage-raphide sacs lessen in number (pith and endocortex).

Histology of the Rhizome.

Sections through an old part of the rhizome reveal the following structure:—

1. A regular *epidermis* with thick cuticularized walls. Here and there cells grow out into "root-hairs."

2. The *cortex* is differentiated more or less in the same style as the root. Externally are a few layers of radially flattened cells, which towards the interior gradually merge into cells polygonal in transverse section; and these in turn are succeeded by cells with thick lignified walls, which are continuous with similar cells in the root. Close to the attachments of a root, the outermost cortical cells are sharply marked off from the cells lying within, and they contain less starch and often distinct mycorhizal hyphæ: that is, there is an exocortex. In these regions they are succeeded internally by a mediocortex with mycelial masses, which are continued from the root. Starch is present most abundantly in the cortex near the region of attachment of the roots, and is conspicuously less in quantity in the immediate neighbourhood of the lateral buds. Large and numerous strings of raphide-mucilage cells occur in the cortex.

There is *no* distinct *endodermis.* The *vascular bundles* are large and numerous. They are typically collateral. Compared with the root and even the inflorescence-axis, there is a large

increase in the elements of the xylem. Each bundle has a large group of wide tracheïdes, and protoxylem in the form of spiral vessels. The phloëm, too, is well developed, and consists of sieve-tubes, companion-cells, and parenchyma. The vascular bundles are embedded in lignified parenchyma. Towards the attachment of the buds and of the inflorescence-axis, the lignification of the ground-tissue diminishes.

Structure of the Flowering Axis.

In my specimen there was only one flowering axis, five inches in length, and bearing three large fruits. From its base adventitious roots arise. The scale-leaves are attached close together at the base, but higher up they dwindle in size and are separated by longer internodes.

Taking sections about halfway up this axis, the structure revealed is as follows:—

1. *Epidermis* composed of narrow cells much elongated longitudinally, with thick heavily cuticularized outer walls. The cuticularization is continued into the lateral walls. No stomata occur. Even at this height, pegs similar to those formed by mycorhizal hyphæ in the root and rhizome are found.

2. *Cortex* made up of cells elongated longitudinally. Externally are a number of layers of collenchymatous cells with small intercellular spaces. Travelling inwards from the epidermis, the collenchymatous thickenings diminish and the intercellular spaces increase in size, but are small at their maximum. Then succeeds a *general sheath* composed of several layers of sclerenchymatous fibres, with small lumina and with very small intercellular spaces. No thin-walled cells interrupt this sheath.

3. Embedded in this sheath and lying in the stelar parenchyma are numerous vascular bundles.

There is only a small central mass of parenchyma free from bundles. No starch occurs. Only a few isolated mucilage-cells are present, so that transverse sections may be taken in which no mucilage-cells are visible.

Structure of the Vascular Bundles (Pl. IV. fig. 3).—Each bundle is collateral and has a sheath of sclerenchymatous fibres round it.

The *phloëm* consists of sieve-tubes with terminal and oblique sieve-areas, long companion-cells with elongated narrow nuclei,

and longitudinally extended parenchymatous cells. The protophloëm is crushed and stains bright blue with aniline-blue.

The *xylem* is mainly constituted of tracheïdes forming an uninterrupted mass. They have transverse pits. The tracheïdes are separated from the phloëm by long parenchymatous cells. Here and there between the tracheïdes and the sheath are wood-parenchyma cells. In the larger central bundles the protoxylem is visible in the form of curious narrow vessels, having very loose thickenings (spiral, annular, reticulate), which may be described as tangled. A small intercellular space denotes that there has been an attempt to form the typical schizo-lysigenous intercellular space. In some of these larger bundles, radially within this protoxylem, there is a collection of elongated parenchymatous cells with narrow lumina which strongly resemble the phloëm. I never succeeded in discovering sieve-tubes amongst these cells, though they possibly occur. Such bundles, then, are probably bicollateral. The outer vascular bundles are smaller, and near the general sheath some of them consist solely of phloëm.

In the uninjured axis I could detect the entrance of fungal hyphæ in a few isolated spots, and the attacked cells acquired very thick suberized walls which soon prevented the hyphæ penetrating more deeply. But part of the axis had been mechanically injured some distance up. The wound was closed over by a false epidermis. At certain points hyphæ had penetrated and descended even as deep as the sheaths of the vascular bundles. The walls of the cells attacked had become decolorized and the contents disorganized and coloured brown. Of course it was impossible to decide whether or not these hyphæ belonged to the mycorhizal fungus. The injury undoubtedly was not initiated by a fungus. This shows that the thick cuticularized epidermal walls normally can act as a shield to ward off fungal attacks.

This account of the structure of the middle part of the inflorescence-axis holds for the rest of the axis, except for some differences with reference to the mechanical cells, raphide-mucilage cells, and the distribution of starch.

At the basis of the axis, *mechanical cells* with wide lumina form two or three layers round the general sclerenchyma-sheath; these disappear higher up the axis. But an interesting change in structure again takes place at the region of attachment of each fruit. In relation to the diameter of the axis, the fruits are disproportionately large and heavy because of the large amount of water in them. We might anticipate that additional pro-

visions would be made to ensure the firm attachment of the fruits. Each fruit is attached by a short almost imperceptible pedicel, and there is a distinct constriction marking the point of junction of the fruit and the pedicel. In the pedicel the whole of the parenchymatous ground-tissue, excepting 2–3 external cortical layers, is converted into mechanical tissue composed of short square cells with very thick, pitted, and lignified walls. At the constriction, the whole of the ground-tissue is thus modified. This mass of sclerenchyma penetrates the base of the fruit in the form of a short cone. Further, it is continued down the main axis, but only on the side on which the fruit is attached.

The *distribution of starch and raphide-mucilage cells* varies in the different parts. The mucilage-cells are especially collected in the cortex. At the base of the axis, where roots are attached and the scales set closely together, it is easy to take a transverse section, so that a root is coming off from one side and a leaf from the other. On the root-side the cortex is packed with starch-grains. On the leaf-side not a grain of starch occurs in the cortex, though some grains are present in the nerve-parenchyma of the vascular bundles running out to the leaves. In the more central ground-tissue amongst the vascular bundles the starch increases towards the root and dwindles towards the leaf. (Starch is of course richly present in the cortex of the roots.) Similarly that half of the axis connected with the root has many large raphide-mucilage cells; on the side towards the leaf there are only a few small raphide-mucilage sacs.

Half an inch above the region where the scales are closely set, starch occurs in the inner cortical cells around the general sheath and in the stelar ground-parenchyma. Raphide-mucilage cells occur and invade even the general sclerenchyma-sheath.

An inch higher starch occurs solely in a few of the stelar ground-parenchyma cells, and there are only a few mucilage-cells (three in a transverse section) without raphides.

Then succeeds a region in which there is no starch, and mucilage-cells are very scarce and isolated (often none visible in a transverse section). At this region the leaves have series of raphide-mucilage cells. Higher up, near the attachment of the fruits, the mucilage-sacs increase in number, though there is no starch. But in the pedicel the sacs are absent.

In specimen B, above the region of attachment of the roots, only a small amount of starch occurred, and that was confined

to isolated parenchyma-cells just outside the general sclerenchyma-sheath. A few raphide-mucilage sacs occurred all the way up the flowering axis.

Hitherto no reference has been made to some structures which occur on the upper parts of the flowering axis, namely certain *hairs*. In the fruiting specimen they are visible merely as numerous crushed hairs on the fruit-bearing part of the axis. They are entirely absent from the subterranean part of the plant, rhizome, or buds. In specimen B their structure can be made out. They are glandular hairs coating the upper parts of the axis, the ovary, and the perianth-leaves. They secrete mucilage. Each hair is composed of a single row of swollen spherical cells. Each cell has a large central nucleus slung by thick bridles of protoplasm to the general peripheral lining of protoplasm. On these bridles minute clear bubbles are visible (mucilage ?).

Histology of the Scales.

All the scales are more or less closely adpressed to the axis which bears them. Thus the lower surface is exposed and the upper surface lies against the axis, or axillary bud.

As there are considerable differences between the structure of a bract and of a subterranean leaf, the two will be described separately.

Structure of a Bract (Pl. IV. fig. 4).—At the base of the bract the inner (upper) epidermis has relatively thin walls not much cuticularized. Some of the cells grow out into secreting hairs.

The mesophyll is composed of 6–7 layers of parenchymatous cells with small collenchymatous thickenings and feebly developed intercellular spaces. The layer immediately within the inner epidermis is flattened. All the cells composing the mesophyll have well-marked nuclei, and in the cytoplasm excessively fine deeper-staining filaments are visible.

The outer (lower) epidermis has walls which are much thicker and more heavily cuticularized than the inner epidermis. In these, fungal pegs are frequently visible. Some of these cells contain hyphæ and have brown walls; and in some places the hyphæ have penetrated to a depth of three layers in the mesophyll, the attacked cells having discoloured walls and disorganized contents.

Towards the margins the scales become thinner, having fewer layers of mesophyll; and the inner epidermis acquires more thickly cuticularized walls. Most of the cells in these thinner

regions of the scales have brown walls and contain hyphæ. Raphide-mucilage sacs occur in the mesophyll of the scale.

The vascular bundles, at the base, are nearer the upper (inner) face of the leaf, and are separated from the inner epidermis by one or two layers of mesophyll. The bundle is invested with a sheath of sclerenchymatous fibres, which is more strongly developed on the side remote from the inner epidermis. The bundle contains xylem and phloëm, but there is relatively little phloëm. Within the sheath on the upper (inner) side are some parenchymatous cells longitudinally elongated which contain starch. Within these lie the xylem, commencing with narrow spiral vessels and followed by tracheïdes. Parenchyma-cells separate the xylem from the phloëm with sieve-tubes. Separating the phloëm from the sheath again is a more or less complete layer of parenchyma-cells which contain starch. (Starch occurs in no other cells of the scale.) In small vascular bundles the phloëm is represented by a mass of very narrow elongated parenchyma-cells.

Following the scale up towards its apex, certain remarkable changes in structure are visible. On the side towards the inner epidermis gaps arise in the sclerenchyma-sheath, and single subepidermal cells are changed into broad storage-tracheïdes which are connected with the xylem of the bundle. Ascending higher, the bundle-sheath disappears and there is developed within the inner epidermis a complete network of these tracheïdes, which are connected with the xylem of the bundles. In transverse section this extrafascicular system of tracheïdes seems to extend like a pair of wings from each bundle, and meet the wings from the adjacent bundles. These tracheïdes are elongated longitudinally and not directed at right angles to the epidermis. There are considerable gaps in the network of tracheïdes which are occupied by ordinary mesophyll-cells. The inner epidermis immediately outside the hypodermal network of tracheïdes has thin feebly cuticularized walls. Nearer the apex and margins of the scale this hypodermal system disappears and the inner epidermis acquires thick walls with a conspicuous cuticle.

The hyphæ penetrate the outer epidermis and the regions near the tip and margins, more abundantly than they do the thin-walled part of the inner epidermis. This may be simply because these parts of the leaves are more exposed. In one bract hyphæ had penetrated the inner epidermis and traversed a series of hypodermal tracheïdes, causing disorganization of the cells attacked.

Thus, even if the fungus were harmless or even useful at first, it eventually kills the cells of the scales in the aerial part of the axis.

Histology of a Subterranean Scale (Pl. IV. fig. 5).—The main scheme of structure is the same as that of a bract, but the subterranean scale is much larger and the hypodermal system of storage-tracheïdes is disproportionately greater. These tracheïdes form, even immediately at the base of the scale, a large and close hypodermal sponge-work several layers thick. There are very few ordinary mesophyll-cells between the tracheïdes, which occupy a space as much as a third of the whole thickness of the leaf. In addition the tracheïdes display a strong tendency to arrange themselves with their long axes at right angles to the surface of the leaf, whereas in the bract the long axes are parallel to the surface.

No hairs occur on these subterranean leaves.

Function of the Leaves and Transpiration.

In the absence of physiological observations, it is only possible to offer suggestions concerning the function of the leaves, the processes of transpiration and of absorption of solutions.

The existence of well-developed xylem, mainly consisting of conducting tracheïdes, must be regarded as evidence for the existence of a considerable current of water from the absorbing parts to the growing portions of the plant. From analogy with other plants we must assume that the parts which absorb are those which contain mycorhizal hyphæ. In spite of their thick walls, the roots and possibly portions of the rhizome absorb, the solution passing in through pits in the walls and probably especially by the agency of the mycorhizal hyphæ.

The question now arises as to how the plant gets rid of the excess of water absorbed. During a considerable portion of its existence, the plant consists merely of its subterranean portion (judging from the analogy of all investigated European saprophytes). Hence during that period the water cannot be disposed of by any aerial part of the plant. The solitary spots in the subterranean plant which are covered by thin and feebly cuticularized walls are the parts of the scale-leaves where a large hypodermal system of tracheïdes is developed. Hence I conclude that these scale-leaves are the organs of transpiration. It should be noted that these subterranean parts grow in positions liable to rapid changes in the moisture. In the first place the

plant is very near the surface of the soil; secondly, the soil is light; and thirdly, the plant grows high up mountains. All these conditions render the substratum liable to rapidly lose water, and expose the plant to the risk of transpiring excessively. So I assume that the following process takes place:—When the soil is damp the roots absorb solutions, a transpiration-current sets in towards the growing parts and leaves in general, the water is carried by the small bundles of xylem into the scales and gradually deposited in the storage-tracheïdes. At this time transpiration is out of the question. Whether the hypodermal tracheïdes finally fill and permit liquid water to be forced out through the thin-walled epidermis it is impossible to say. When the soil dries, transpiration becomes possible. This does not take place from the regions covered by a layer with thick walls, but from those parts of the scales at which the epidermis has thin walls. And this process is aided by the rapid absorption of the exhaled vapour by the hygroscopic soil and its speedy conduction to regions where absorption is taking place.

Considering the plant when it has an inflorescence-axis. There is a considerable current of water as evidenced by the xylem. The axis is coated everywhere with an epidermis with thickly cuticularized walls. The spots from which water can be excreted are the scale-leaves, the mucilage-hairs, and the parts of the flower. As these aerial portions are more liable to lose water than the subterranean portions, and as the floral parts and mucilage-hairs cause the plant to lose water, there is not the same pressing necessity for a large transpiring surface, nor for a large development of storage-tracheïdes. So we find that the scales dwindle in size and number and the system of hypodermal tracheïdes gradually diminishes as we ascend the inflorescence-axis. When the fruits form, the same holds good, for the fruits store up a large amount of water.

Thus the subterranean parts are constructed so as to avoid being dried up and yet to permit of a regulated loss of water. In the inflorescence-axis the arrangements to prevent loss of water are much more marked than the mechanisms to permit transpiration. The plant is a unique xerophyte.

It might be suggested that the subterranean scales are organs of absorption. Possibly they may be so periodically. But the following reasons may be urged against a view that they are essentially organs of absorption:—(i.) That region of them

through which absorption might take place is not freely exposed. (ii.) Mycorhizal hyphæ do not penetrate at the spots where the epidermis has thin walls, although the spaces between the leaves and axis are filled with hyphæ and humus. (iii.) The structure and circumscribed area of the spots of the epidermis where the walls are thin militate against this possible view. (iv.) In the rhizome the accumulation of starch and raphide-mucilage cells is near the attachments of the roots and distant from the scales. (v.) The amount of starch in the scales is small. (vi.) The aerial scales are constructed on the same scheme as the subterranean scales. (vii.) Other saprophytic orchids possess stomata in their subterranean parts, or other means of getting rid of excess of water (storage). None of these considerations disprove the views that the scales can absorb. But that they can lose water seems certain when we ask the question, "If the scales do not get rid of the excess of water, how is that surplus disposed of ?"

Histology of the Fruits. (Pl. V. fig. 9.)

On my specimen there were three succulent fruits shaped like small tapering bananas. The ovary has one loculus, and three branched parietal placentæ bore numerous young seeds.

Sections reveal the following structure:—Externally is an *epidermis* composed of small cells with thick, cuticularized outer walls. Traces of a few *hairs* are visible. Within lie about eight layers of parenchymatous cells. These cells tend to be elongated tangentially (in transverse section) and gradually increase in size towards the interior. They are succeeded by about twice the number of large parenchymatous cells, which are rich in starch excepting immediately in the neighbourhood of the interplacental vascular bundles. Scattered in the parenchymatous *ground-tissue* are longitudinal rows of *mucilage-cells* which appear to have no raphides. In transverse section one sees that there is a single ring of parenchymatous cells elongated radially round each mucilage-cell. Hence it is possible to recognize the latter even when the mucilage has dropped out.

There are *six* main *vascular bundles*, three opposite the three placentæ and three equidistant between these. The ground-tissue cells in the neighbourhood of the bundles change their shapes and gradually become elongated at right angles to the direction of the bundles from which they radiate, forming marked patterns. In the bundles there is a great diminution in the xylem. From

the anti-placental bundles, very small bundles run longitudinally in the placentæ. These small bundles contain no lignified constituents and appear to be solely made up of narrow elongated parenchyma (and sieve-tubes ?).

The *placentæ* are large and branched. Their proximal parts consist mainly of parenchyma and the small bundles. But the larger part of the placentæ is constituted of enormous mucilage-cells (fig. 9), which are ranged in masses rather than in longitudinal rows. Each mucilage-cell contains a large sponge-work of mucilage, a central vacuole in which lies a small dense mass of mucilage*. No raphides occur. A small nucleus lies pressed against the wall of the cell. Between the mucilage-cells are mostly thin-walled flattened cells containing no starch but having granular protoplasm and a large nucleus. In the same part of the placenta, here and there, are strings of smaller cells elongated in a transverse plane and containing starch. They communicate by irregular lines of starch-containing cells with the cells of the proximal portion of the placenta, which also contain starch. In fact they might be termed conducting parenchyma-cells.

At the base of the ovary, where few or no ovules are attached, the small placenta, in transverse section, consists of few (about two) mucilage-cells enveloped by a mass of small parenchyma choked with starch-grains.

The anatropous *seeds* appear to be mature or nearly so. Several layers of cuticularized cells form a testa. A simple undifferentiated embryo without a suspensor fills nearly the whole of the cavity of the seed. A few cells with thin cellulose-walls, scarce any protoplasm, but having sharply-defined nuclei, occupy a small region remote from the micropyle. They appear to represent the remains of the endosperm.

One fruit was considerably decayed in several spots, and particularly near the base, and was half eaten away. The ovules were intact. The exposed cells of the ovary-wall had brown membranes and protoplasmic contents, and on the walls of many of

* Again I must call attention to the fact that the material was fixed with methylated spirits. In some of the mucilage-cells in different parts of the plant the mucilage appeared to be in the form of isolated bubbles lying in a protoplasmic network. But in the majority of cells the network stained red, like the central mass of mucilage. This may be a stage subsequent to the bubble-like condition.

these cells were dark-coloured resistant bubble-like structures of unknown nature. These exposed cells contained starch (even the outer cortical cells); on the other hand, the cells in their immediate vicinity were devoid of starch. Thus the process of decay had caused a flow of carbohydrates to the infected spots, so that the inner cortical cells, which normally have starch, had been locally drained of their starch. Fungal hyphæ were found amongst many of the exposed cells, and there appeared to be traces of mucilaginous degeneration. I am unable to say how far this decay was a natural process, or how far caused by hyphæ.

In specimen B, with young unopened flowers, the ovary has many hairs on the surface, the cortical mucilage-cells contain raphides, and starch occurs only in a single layer of parenchyma round the vascular bundles. Starch occurs nowhere else in the flower except under the papillæ of the stigma.

Final Remarks on Metabolism in Galeola.

Considering the mode of life of *Galeola*, which passes part of its existence as a subterranean plant, and remembering that the thick fleshy roots form by far the greater portion of the subterranean mass, it is natural to assume that in the roots not only does the process of absorption take place but also the processes of anabolism. And this assumption is confirmed by observation of the distribution of starch and raphide-mucilage cells throughout the plant; for these are the solitary substances in this plant by which we can gauge metabolism. Starch and raphide-mucilage cells are abundant in the root, and in their distribution in the whole of the subterranean parts of the plants they correspond with each other. In the inflorescence-axis the parallel dwindling of both tends to show that the axis is merely a conducting and supporting structure. The manufacture of the large fruits is necessarily associated with a large production of protoplasm, and here again there is a reappearance of starch and mucilage (not raphides) in corresponding quantities. Possibly the raphides have been replaced by some other organic salt of calcium.

One noticeable anatomical feature in *Galeola* is the exceedingly feeble development of intercellular spaces. The rate of gaseous interchange will be thus considerably diminished. And,

as Mangin has shown, the total absence of stomata will further depress the process of respiration. One cannot avoid the suggestion that the production of mucilage may have something to do with this difficulty of getting rid of carbonic acid, which is necessarily abundant even inside the plant in the substratum. Where raphides occur, undoubtedly a deleterious excretory product is deposited and held in the mucilage-containing cell till the concentration is sufficient to permit of the formation of crystals, and from this one might conclude that the object of the mucilage was to absorb the liquid excretion. It has been ascertained that the fraction $\frac{CO_2}{O}$ in *Neottia* and *Monotropa* is always less than 1, and may be as low as ·6, which suggests that some excretion is retained in the plant in place of being evolved as carbonic acid*. Alkaloids have been shown to occur markedly in raphide-mucilage cells. But whatever may be the significance of the mucilage-cells, they are not water reservoirs upon which the plant can draw in case of need. Volkens completely disposed of this idea by observing that the mucilage-cells in desert plants retained all their water even when all the rest of the cells had become completely dried up.

APHYLLORCHIS PALLIDA, *Blume*.

Blume first described this saprophytic orchid, and in his 'Orchides de l'Archipel Ind. et du Japon' an admirable illustration of the plant is given (p. 52, plate 13. fig. 1). From this latter work the following description of the vegetative characters of the plant is taken :—

"*Radix* fibris compluribus vermicularibus carnosis albidis villosiusculis horizontaliter extensis composita.

"*Scapus* solitarius, pedalis, rectus, teres, pallidus, obsolete purpurascenti-striolatus, inferne glaber, vaginulis alternis remotis tubulosis membranaceis, ore oblique truncatis arcte cinctus, superne simpliciter racemosus et nonnihil fusco-leprosus . . ."

Blume does not mention the occurrence of chlorophyll in any

* Aquatic plants have difficulty in obtaining gases essential. And it seems possible that the mucilaginous envelope often found on them is for the purpose of absorbing or entangling gases, especially carbonic acid. But in this case the carbonic acid would be ultimately handed over to the plants under the influence of light.

part of the plant. Yet in his figure the ovary and the base of each bract is painted green.

As the habitat of the plant Blume mentions the forests of high mountains in Java.

The several specimens which I investigated were in flower. And I may supplement Blume's description by a few remarks on the external morphology of the plant.

The subterranean part of the plant consists of a small cylindrical rhizome with minute scale-leaves. From this radiate the long simple unbranched* roots which extend horizontally close under the surface of the soil.

Above the attachment of the roots, at the base of the scape, the scale-leaves are larger and sheathing.

The form of the saprophyte does not differ so much from that of a green terrestrial orchid as does *Galeola*. There is no great disproportion between the size and form of the subterranean and aerial parts of the plant. In fact, judging from the small size of the rhizome, the fair size of the sheathing-scales, one might not surmise, from alcohol specimens, that the plant contained little or no chlorophyll. Corresponding to this lack of any striking morphological peculiarities, the plant displays histological structure which deviates but slightly from that of green plants.

Histology of the Root.

A mature part of the root displays the following structure:—

A *piliferous layer* is represented by a single layer, which is preserved in patches. Some cells are flattened, and others are prolonged into root-hairs. The latter have thick suberized walls which are pierced by mycorhizal hyphæ. The hyphæ can be traced *from the hairs* into the deeper tissues of the root.

There is a definite *exodermis* with small protoplasmic passage-cells which are traversed by mycorhizal hyphæ.

There succeeds a distinct *exocortex* composed of two or three layers of radially flattened cells. Raphide-mucilage cells form longitudinal rows in this layer, but do not occur elsewhere in the root. The innermost layer often has elongated mycelial masses. In the growing point the exocortex is marked off from the mediocortex in that the mycelial masses form very much

* At the base of one root I found the rudiment of a lateral root. It was forming in the pericycle and had a distinct digestive sac.

earlier in the latter, in the exocortex the mycorhizal hyphæ remain distinct for a lengthy period.

Within the exocortex there lie about eight layers of parenchymatous cells which are isodiametral in transverse section. Of these five to six outer layers form the *mediocortex*, and contain glistening yellow mycelial masses. The remaining two or three layers have no mycelia, and form an *endocortex*. The cells composing the endocortex contain starch, which is found nowhere else in the root.

There is a well-marked *endodermis*. Its cells are longitudinally elongated. Outside the phloëm the walls (Pl. V. fig. 1) are more thickened. Some of the cells opposite the xylem are passage-cells with large nuclei and very thin suberized walls (fig. 1).

The *pericycle* is composed of a single layer of brick-shaped cells. Some of these cells have thin cellulose walls and rich protoplasmic contents. But typically the cells of the pericycle, which are on the radii between the bundles of xylem and phloëm, have lignified, thick, pitted walls.

The root is pentarch, the whole of the tissue within the pericycle is lignified excepting the bundles of phloëm.

Outside each bundle of xylem lie, in transverse section, about three pericycle-cells with thin unmodified walls. As the ground-tissue cells radiating out from the xylem towards the pericycle on each side are lignified, each bundle, in transverse section, looks as if it were forked outwards. At certain spots these lignified forks are interrupted by cells with thinner, but still lignified walls, so that they permit of communication between the phloëm and the pericyle which is outside the xylem.

The conducting elements of the *xylem* are made up of tracheïdes with transverse pits, and towards the interior there are in addition fibro-tracheïdes with fewer pits, which are, however, bordered.

Outside each bundle of *phloëm* there lie, in transverse section, about three pericycle cells, of which the two lateral, or all three, have lignified walls. The phloëm consists of a mass of delicate tissue with thin cellulose-walls: sieve-tubes with oblique terminal plates, companion cells with strap-like nuclei, and elongated parenchymatous cells with wider lumina and oval nuclei.

The whole of the *conjunctive tissue* and the *pith* is converted into longitudinally elongated cells with thick, pitted, lignified walls.

Within the whole root the intercellular spaces are small.

Apex of the Root.

In longitudinal section the growing point of the root appears very like that of *Zea Mays*, though I could not establish the differentiation of the three histogens. The exocortex is very early differentiated. Mycelial masses occur only in the mediocortex; and starch-grains solely in the endocortex, extending about as near the actual root-tip as do the mycelial masses.

Origin of the Roots.

I saw one root developing at the base of an old root, in the pericycle. The roots then, sometimes at any rate, are endogenous in origin. I did not see the mode of development in typical cases, *i. e.* from the rhizome.

Histology of the Inflorescence—Axis or Scape.

Traced upwards, the scape tapers till it becomes thin and whip-like. A description will be given first of the structure of the scape at its full thickness, four inches above the attachment of roots, and considerably below the flower-bearing region.

1. The *epidermis* consists of narrow longitudinally-elongated cells, with a cuticle on the outer walls, which are only moderately thick. A few shrivelled hairs remain. Here and there *stomata* are visible often with starch in their guard-cells.

2. The *cortex* commences with two layers of parenchymatous cells with thin unmodified walls and small intercellular spaces. Some of the hypodermal cells form isolated raphide-mucilage sacs.

3. These layers are succeeded by the *general sclerenchymatous sheath* of 3–4 layers of fibres. In iodized chloride of zinc it is easy to establish the fact that the small pits of these fibres are lined with cellulose, and the pits are further connected with one another by thin vertical or horizontal threads of cellulose traversing the inner surface of the wall. Thus in a surface view of a fibre the walls appear to have a peculiar network of cellulose with regular square meshes.

4. The *vascular bundles* lie scattered in the parenchymatous ground-tissue of the stele, and there is a distinct central region (pith) devoid of bundles.

Histology of the Vascular Bundles (Pl. V. fig. 2).—Each bundle is surrounded by a more or less imperfect sheath of sclerenchymatous fibres. The lignification and thickening of the

cells forming this sheath are more marked on the radially external part of the bundle.

The *phloëm* consists of sieve-tubes, companion cells, and elongated parenchymatous cells similar to those occurring in the root. But the last-named have wider lumina and very large oval nuclei.

The *xylem* is separated from the phloëm by a transverse band (in transverse section) of longitudinally elongated parenchymatous cells with peculiar square nuclei. Within succeeds a single, or double, tangentially extended line of tracheæ with transverse pits. The protoxylem is clearly represented by a radial series (fig. 11) of spiral and annular vessels lying in a mass of parenchyma with thin unmodified walls.

Histology of the Rhizome
(at or below the attachment of the highest roots).

Compared with the scape, there is a large increase in the size of the cortex and a dwindling of the stele. The cortex, outside the general sheath, is constituted of nine layers of parenchyma which is rich in starch. Further, the ground-tissue within the stele is changed into parenchymatous cells with thick lignified and pitted walls. These are easily distinguished from the sheath-fibres by their wider lumina and lack of narrow pointed ends.

In one rhizome I found a young bud had been adventitiously produced from a terminal scar where the rhizome was undergoing decay. Similar buds are produced from isolated broken fragments of the rhizome of *Lathræa squamaria.*

Histology of the Upper Parts of the Scape.

The diminution in thickness in the higher regions of the scape is due to the reduction of the size of the stele, within which there are fewer vascular bundles. The bundles are smaller, and the reduction of the xylem is most marked. The cells of the general sheath and of the bundle-sheaths have thinner walls than lower down. Hairs and stomata occur. Such is the appearance of the upper part of an old scape bearing fruits and mature flowers. But when the scape terminates in a bud containing rudiments of flowers, the appearances are different. The young parts of the scape and the inner faces of the young scales are coated with *glandular hairs pouring out mucilage.* Thus the

spaces between the sheathing scale-leaves and the axis are filled with mucilage. The *hairs* are directed upwards and pressed against the surface. Each hair consists of a row of cells. In slightly older parts of the bud the hairs consist of fewer cells, and often the terminal cells may be seen to have burst. This suggests that mucilage is produced successively in the cells of the hair, the process commencing at the distal terminal cell, which is the first to be thrown off, and gradually travelling down to the other cells. One peculiarity in these hairs on the scales is that the lateral and lower walls of the basal cell are thick and cuticularized; but peculiar slit-like pits in the lateral walls place the cell in communication with the adjoining epidermal cells, though not in communication with the hypodermal cells.

The *distribution of starch in the scape* is interesting. A short distance below the actual apex in the bud there is starch in the ground-tissue, but not in the epidermis. The hypoderma is poor in starch, probably because it is being drained by the hairs for the purpose of manufacturing mucilage. The cells composing the immature general sheath are richest in starch.

Lower down there is no starch, save in the guard-cells of the stomata, till we approach the rhizome, where starch reappears in the cortex.

The hairs are transitory, but, in contrast to those of *Galeola*, they arise on all parts of the shoot-axis, and are not confined to the upper portion of the inflorescence-axis.

Histology of the Scales.

(I.) *Scale well below the floral region of the scape.*—The scale is constituted of about seven layers of cells:—1. The outer (lower) *epidermis* has cuticularized outer walls which are not thick. There are a few remnants of *hairs*, and a good number of *stomata*, which are much more numerous than on the corresponding part of the axis. The form of the stomata and the guard-cells varies greatly (Pl. V. figs. 3 *a*, *b*, *c*, *d*), so that some of these stomata are certainly amongst the most unique known. The variability in form of the stomata suggests that we may be dealing with structures which are undergoing functional atrophy. The stomata are raised on slight eminences and the guard-cells protrude. Beneath each stoma there is an intercellular space of relatively large size. The guard-cells have large chromatophores (plastids), which often are packed with minute starch-grains. 2. The *meso-*

phyll consists of about five layers of cells with delicate walls and small intercellular spaces. Many isolated *raphide-mucilage cells* occur in the layer beneath the outer epidermis. 3. The *vascular bundles* are closely approximated to the upper (inner) epidermis, being separated from it by, at the most, one layer of cells. They are small and simple. In the larger bundles, in transverse section, towards the lower (outer) epidermis there is an arc of lignified sheath-cells. The *xylem* is represented by a few narrow spiral vessels or tracheïdes. The *phloëm* is excessively feebly developed. 4. The inner (upper) *epidermis* consists of flat cells with thin walls. Stomata are wanting, or occur sparsely towards the free margins. On the other hand, the remnants of *hairs* are more numerous than on the outer face of the scale.

The *bracts* are histologically similar.

The *subterranean scale-leaves* are like the aerial leaves, and their stomata are widely open and numerous. Remains of glandular hairs are found in the inner face of the scales.

Distribution of Starch in Young Scales of the Scape.

In the smallest rudiments of the scales forming a bud there is no starch. In slightly older, developing, scales starch occurs throughout the mesophyll and epidermis (not in the hairs), but it is more abundant in the upper (inner) half of the leaf: that is, on the half towards the glandular hairs. In still older scales this difference is more marked; the starch has deserted the lower (outer) half of the leaf, and none is found in the outer epidermis save in the guard-cells. On the other hand, there is a large quantity of starch in the inner epidermis. In yet older scales most of the starch is confined to the upper (inner) epidermis; there is little or none elsewhere excepting in the guard-cells of the stomata. Finally, in mature leaves, in which the secretion from the hairs on the inner face has stopped, the starch has vanished from the inner epidermis. Thus it appears that in the scales the distribution of starch has relation to the mucilage-secreting hairs. There are very few hairs on the outer surface, but many on the inner face. There is constantly, then, a flow of carbohydrate material to the inner face. It will be noted that this assumption that the starch is consumed to manufacture mucilage is confirmed by the peculiar mode of disappearance of the starch. Histologically I showed that conduction of material into the hairs must take place from the adjoining epidermal cells,

not from the hypodermal cells. Corresponding to this is the fact that the starch disappears latest in the inner epidermis.

Histology of the Fertilized Ovary.

The ovary is unilocular, with three parietal placentæ, which bear numerous ovules. The wall of the ovary consists of the external and internal epidermis, and parenchyma forming the ground tissue in which lie six vascular bundles, three anteplacental and three interplacental. Opposite each vascular bundle the wall of the ovary is ridged, but the interplacental ridges might be more aptly described as ribs, as they are longitudinal outgrowths attached merely by a narrow line or neck of tissue (Pl. V. fig. 4).

Histology of the Interplacental Ridge.—Outside are large epidermal cells which become small at the neck (Pl. V. fig. 4). Within succeed about three layers of parenchyma-cells isodiametral in transverse section. These dwindle in size towards the flanks of the vascular bundle which lies at the constricted portion of the ridge. On the inner side of the vascular bundle are three layers of small parenchymatous cells, within which is the internal epidermis, made up of short, small cells lining the cavity of the ovary at this point. Starch occurs mainly or solely in the middle layer of parenchyma on the outer side of the bundle, and in the cells of the internal epidermis.

Histology of the Anteplacental Ridge.—This has no narrow neck. The vascular bundle is surrounded by about three layers of large parenchymatous cells containing starch, which is also found in the parenchyma forming the proximal portion of the placenta.

The *tissue connecting the inter- and ante-placental ridges* is peculiar. Commencing at the interplacental region, the cells of the internal epidermis suddenly change their shape and direction. They become elongated transversely to the long axis of the ovary and parallel with the surface. The ground-tissue cells outside then undergo a similar change, so that the inner half of this tissue is made up of conducting parenchyma, the cells of which are elongated at right angles to the course of the vascular bundles and contain starch. They are continued from the small starchless parenchyma lying within the interplacental ridges to the large starch-containing parenchyma round the anteplacental bundles. At the interplacental region the change from the

starchless cells inside the ridge to the elongated conducting parenchyma with starch is sudden, and corresponds with constriction of the ridge. At the constriction itself all the cells, including the epidermal, have starch, and the starch-containing cells on the other side of the bundle here are joined to the outer epidermis (Pl. V. fig. 4). The outer half of the tissue connecting the two ridges is devoid of starch, and is constituted of the outer epidermis and two layers of large parenchymatous cells. Some of the latter contain raphides and mucilage. These histological details suggest that, when the fruit is developing, the plastic products carried up by the interplacental bundles are rapidly transferred to the placentæ by the peculiarly developed conducting parenchyma-cells, and that even the inner epidermis plays the same *rôle* of conduction.

General Remarks on Aphyllorchis.

On the whole, histological evidence confirms the view gained from the examination of the grosser morphology of *Aphyllorchis*: that is, that the loss of chlorophyll has not been associated with any fundamental changes in the structure of the plant. It is hence possible that we are dealing with a holosaprophyte which has tolerably recently lost its power of assimilating carbonic acid. The points in which the plant resembles a typical autotrophic plant or a green orchid are: a full development of root-hairs, the occurrence of a typical exodermis, normal vascular bundles, and stomata. With reference to the occurrence of stomata, they do not alone denote that the plant has only recently lost its chlorophyll; for stomata occur in the much modified holosaprophyte, *Epipogum aphyllum*, on the rhizome, and still more remarkably on the curious holoparasitic *Lennoaceæ*.

The occurrence of well differentiated water-conducting constituents in the xylem renders it highly probable that there is a considerable transpiration-current. Doubtless the widely open stomata on the subterranean scale-leaves and those on the aerial parts of the shoot enable the plant to get rid of its excess of water. The presence of distinct intercellular spaces under these stomata does not necessarily imply that the water is sent out in a gaseous form, though it may at first seem more probable. Clearly, then, in this plant the leaves, as in *Galeola*, are essentially the organs of transpiration for the plant; and, just as in *Galeola*, there is a relative dwindling of the phloëm in the bundles of the

leaf. The plant as a whole is less xerophytic in structure than is *Galeola*; everywhere it is coated with an external layer of cells which have walls thinner and less cuticularized than in *Galeola* (excepting the isolated spots on the scales of the latter). Whether this is to be associated with the particular nature and habitats of the two plants, or with the fact that *Aphyllorchis* has a more extensive absorbing surface, it is impossible to say.

Lecanorchis malaccensis, *Ridl.*

This holosaprophytic orchid was first described by Mr. H. N. Ridley in the Transactions of this Society, 2nd ser., Bot. vol. iii. p. 377, and he was good enough to send me one of his specimens. Plate 65 in Mr. Ridley's paper represents the specimen, and shows a descending rhizome to which are attached a number of feebly branching, horizontally extended roots. Two inflorescence-axes rise from one end of the rhizome.

Histology of the Root.

The adventitious roots of this plant are long, feebly branched, slightly succulent, and extend horizontally from the vertically descending rhizome.

Externally the whole root-system—the young parts as well as the old—is coated with a dense covering of particles of humus. This suggests that the older portions of the roots are able to absorb, just as are the younger, and histological investigation confirms this view.

To describe first the structure of a mature part of the root:—

(1) The piliferous layer is represented by a single layer of cells. None of these cells grow out into root-hairs. In most regions of the roots this layer persists, though here and there are patches where the cells have been partially disintegrated, so that only their lateral and inner walls persist. The cells are elongated in the direction of the root-axis; their walls are thin, but lignified, and a delicate cuticle clothes them externally. The walls are not evenly thickened; delicate filamentous thickenings mark the longitudinal walls in a direction at right angles to their length (Pl. V. fig. 5). Most of the cells are devoid of protoplasm, but isolated cells outside the passage-cells of the exodermis are shorter, with more evenly thickened walls, and retain their protoplasm and a clearly defined nucleus. Thus the *piliferous layer is represented by a slightly modified velamen con-*

sisting of one layer of cells. Mycorhizal hyphæ may be seen outside the roots and penetrating and traversing many of these cells.

(2) *Exodermis* (Pl. V. fig. 5).—This forms a remarkably distinct and regular layer of cells. Most of its cells are elongated longitudinally, and their radial diameters are longer than their tangential; they have very thick, stratified, cuticularized walls, with middle lamellæ, which are lignified excepting towards the subjacent cortical cells. The lateral and internal walls have simple pits; the external walls are not pitted. Scattered amongst these cells are the smaller passage-cells, with thin lignified walls and dense protoplasmic contents. Each passage-cell is shaped like a truncate cone with the broad base inwards. Its lateral walls have numerous simple pits, placing it in communication with the adjoining exodermal cells. To render the inflow of liquids still more easy, the inner wall of the passage-cell is frequently pitted.

The majority of the mycorhizal hyphæ pass in *viâ* the passage-cells, but a few pierce the other exodermal cells.

Within the exodermis there succeed about eight layers of cortical parenchyma, the cells of which have thin, pitted, cellulose-walls. Of these about four layers form an

(3) *Exocortex*, which is made of cells which are more elongated and narrower than those comprising the inner portion of the cortex. Many of these cells have coiled mycorhizal hyphæ, and amongst them occur scattered raphide-mucilage cells. In my specimen, which was in blossom, no starch occurred in these cells.

(4) The *inner portion of the cortex* is constituted of broader and shorter cells, excepting those immediately outside the passage-cells of the endodermis, which are narrow. In mature parts of the roots of my specimen neither starch nor mycelial masses occurred. In the youngest parts of the roots mycelial masses were to be seen in all stages of formation. The change in the nuclei of the cells in which the masses were commencing was striking. The nuclei evidently increase in size, and become packed with relatively very large, deeply staining granules. In these young parts of the root mycelial masses occurred in all the layers of the inner portion of the cortex, including the layer immediately outside the endodermis. Thus there is *no distinction into a mediocortex and an endocortex.* It is to be noted that in the mature parts of the roots of this plant not a grain of starch was visible, nor was there a trace of mycelial masses. This plant was just at that stage during which it would

be most rapidly draining the roots of any plastic products, *i.e.* it was flowering (*cf.* the disappearance of starch in rhizome of *Corallorhiza* only when the flowers are forming). It may be suggested that the mycelial masses also have been absorbed from all parts of the roots save the youngest.

(5) *Endodermis* (Pl. V. fig. 6).—In transverse section this single layer has an exceedingly characteristic appearance; it belongs to the C-type, with the lateral and inner walls thickened. The cells composing this layer are of unequal size. Outside each bundle of phloëm there may (still in transverse section) be either one or two large endodermal cells with very thick suberized C-walls. On each side, going towards the xylem radii, the endodermal cells dwindle in size and their walls become thinner. Outside each group of xylem stand one or two passage-cells with feebly suberized walls. Longitudinal sections reveal the fact that the endodermal cells are elongated in the direction of the axis, and that the passage-cells form, not isolated spots but continuous lines or bands, outside the bundles of xylem.

The *stele* commences with a

(6) *Pericycle*, a single layer of short parenchymatous cells. Outside the bundles of phloëm these have thick, lignified, pitted walls. Outside the bundles of xylem some of the cells retain their thin, unmodified, cellulose-walls.

The central cylinder is pentarch, and the whole of the conjunctive tissue is constituted of sclerenchymatous fibres. Thus it comes that the five feeble bundles of phloëm are completely encased in cells with thick lignified walls.

(7) Each bundle of *phloëm* consists of a few narrow sieve-tubes, fine companion cells with strap-like nuclei, and elongated parenchymatous cells with oval nuclei.

(8) Each bundle of *xylem* shows an increase in the calibre of the water-conducting constituents from without inwards. These form a radial row, and appear to be tracheo-tracheïdes.

(9) The bundles of xylem do not meet in the centre, so that there is a *sclerenchymatous pith.*

The intercellular system is not well developed in the cortex, and it almost completely disappears within the stele.

At the *base of the root* the inner layers of the cortex are converted into mechanical tissue composed of cells with thick lignified walls.

I had only one uninjured *root-tip* at my disposal. All that I can safely say with reference to it is that a root-cap was present.

Several roots showed processes of decay commencing at their apices. Fungal hyphæ made their way most rapidly up the stelar tissue; they traversed the cortex more slowly, as the cortical cells temporarily parried the attack by a thickening of their walls at the point of contact with the hyphæ.

Histology of the Shoot.

(i.) *Inflorescence-axis.*

(A) *Basal region* immediately above the attachment of the roots.

The axis is externally clothed by an

(1) *Epidermis* composed of longitudinally extended narrow cells. The walls have a tolerably thick cuticle, and the lateral and inner walls are suberized. The walls are in addition coloured blackish-brown, possibly owing to attacks by fungi. *Stomata* are present, and there appear to be traces of decayed hairs. (2) Within succeed some layers of *parenchyma* with thin walls, elongated longitudinally, and polygonal in transverse section. Raphide-mucilage cells occur isolated amongst these. (3) There is a *general sclerenchymatous sheath*, composed of about five layers of fibres. Towards the interior, these gradually pass into (4) the conjunctive parenchyma of the stele, the cells of which have thick, pitted, lignified walls. In comparison with the general sheath the conjunctive tissue is made up of shorter cells with wider lumina, and the intercellular spaces between them are better developed. (5) The scattered *vascular bundles* are larger than in the root. The vascular bundles lying near the general sheath are more or less collateral, but in transverse section are often peripherally elongated rather than radially extended. Towards the centre the bundles are not collateral, but display curious arrangements, which may be roughly described as transitions from a radial to a collateral arrangement, the xylem and phloëm being more or less intermingled. Pl. V. fig. 7 shows a bundle which is almost collateral, but the protoxylem does not lie exactly on the same radius as the phloëm. The *phloëm*, in comparison with that in the root, is relatively more increased than is the xylem. It consists of considerable masses of elongated

parenchyma, some narrow sieve-tubes and companion-cells. The *xylem*, in contrast to that of the root, contains a protoxylem formed of spiral, tangled, or annular vessels. In addition there are tracheïdes with transverse pits.

(B) *Higher up*, where the leaves are separated by long internodes, the axis is considerably thinner than at the base.

(1) The *epidermal cells* have very much thicker walls (Pl. V. fig. 8). There is an extremely thick cuticle. The outermost layer of the wall is coloured deep brown; within this the outer wall and the lateral and inner walls are suberized and are pale in tint. Only very few *stomata* occur in this region. (2) The number of *cortical parenchymatous* cells with thin cellulose-walls has diminished to one. (3) The *general sclerenchymatous sheath* is made up of three to four layers of fibres with enormously thickened, glistening, stratified, pitted walls, and small lumina. (4) The stelar conjunctive tissue is sharply marked off from the general sheath, and consists of elongated parenchyma-cells with thin walls. The scattered vascular bundles are small. (5) The *vascular bundles* are collateral, but possess no sheaths of their own. The *phloëm* is well developed, and is separated from the *xylem* by a layer of elongated parenchyma, the cells of which have thin, pitted, cellulose-walls. In the larger central bundles protoxylem in the form of spiral vessels is embedded amongst elongated narrow parenchymatous cells [phloëm (?): I saw no sieve-tubes amongst these].

(ii.) *Histology of the Rhizome.*

Compared with the base of the inflorescence-axis the rhizome possesses more numerous leaves, and from it radiate numerous roots. The vascular bundles running out to these complicate the structure of the rhizome. Compared with the floral axis, all the constituent cells are shorter in an axial direction, more numerous layers of the cortex have their walls lignified, so that there remains but one cortical layer with walls of cellulose. In the vascular bundles the xylem (tracheïdes and spiral vessels) is developed better than in any other part of the plant.

(iii.) *Structure of the Scales.*

The scales have sheathing bases which are pressed against the axis. Each consists of an upper (inner) *epidermis*, a lower

(outer) *epidermis,* and a *mesophyll* composed of slightly elongated parenchymatous cells, amongst which the vascular bundles run. *Raphide-mucilage cells* occur in the mesophyll, and are more numerous than in the neighbouring portions of the axis. The outer epidermis has thicker, more heavily cuticularized walls than has the inner epidermis. *Stomata* occur in the outer epidermis only, being most numerous in the subterranean scales, and constantly decreasing in number higher up the axis. Their shapes are varied and they remarkably resemble those of *Aphyllorchis.* The *vascular bundles* run nearer the upper (inner) surface of the leaves. When entering the leaves possess tracheïdes and spiral vessels, sieve-tubes, parenchyma-cells. In the finer bundles the spiral vessels disappear, and the phloëm is represented by a mass of parenchyma, but the tracheïdes increase in number, and when the phloëm is completely lost the bundles consist solely of a number of tracheïdes running immediately within the inner epidermis. Thus there is a *hypodermal of tracheïdes like that in Galeola.* And, just as in *Galeola,* this system is most extensively developed in the subterranean scales and least in the bracts. In fact, high up the inflorescence-axis this system is, in parts of the leaf, only represented by single tracheïdes completely isolated from the vascular bundles: thus, as in *Galeola,* some of the mesophyll-cells are converted into tracheïdes.

It is worthy of note that, going from the rhizome to the top of the inflorescence-axis, the scales diminish in size and number, the stomata on the scales and axis also decrease in number, the hypodermal tracheïdes of the scales dwindle, the cuticle of the axis becomes very much thicker, and the water-conducting xylem dwindles. These facts again suggest that the leaves are organs by which the plant rids itself of any excess of water. Side by side with these histological changes there is a concentration of mechanical tissue into the general sclerenchyma-sheath, which acquires thicker walls, and at the same time a dwindling of the cortex outside this sheath.

In my specimens fungal hyphæ had penetrated all the scale-leaves *viâ* the inner epidermis. High up the inflorescence-axis I saw hyphæ running up the xylem, but nowhere else in the sections. So I suppose that the hyphæ could only gain entrance by means of the scale-leaves, and, traversing the leaf-bundles, they reached the bundles of the axis without being obliged to pierce the apparently impenetrable general sheath.

General Remarks on Lecanorchis.

Lecanorchis reminds one alternately of *Aphyllorchis* and of *Galeola*. In general shape, and the possession of curious stomata, it vividly recalls *Aphyllorchis*. In its strongly xerophytic structure—for a strong cuticle coats the shoot as a whole—and in particular in the hypodermal tracheïdes of the scales, it resembles *Galeola*. It differs, however, from both plants in the curious modified velamen which clothes its roots, and in the absence of any root-hairs.

Epipogum nutans, *Reichb. f.* (Galera nutans, *Blume*).

The genus *Epipogum* includes two species: the one, *E. aphyllum*, being distributed over Europe and Northern Asia; the other, *E. nutans*, found in tropical Asia, Africa, and Australia.

Of *E. nutans* Blume speaks as follows:—

"*Habit*. Semel tantum in eam incidi in declivibus uvidis ad montem Salak Javæ occidentalis, mense Novembris florentem.

"*Descr. Tuber* solitarium, sesquipollicare, elongato-ellipsoideum, obtusum, terræ oblique immersum, solidum, carnosum, intus albidum, extus fuscum, obsolete annulatum. *Scapus* circiter pedalis, crassitieæ pennæ cygneæ, teres, fistulosus, eburneus, semipellucidus sive florum instar aspectus quasi vitrei, inferne rectus ac squamis aliquot distantibus amplexicaulibus obtusis tenuissimis membranaceis primo appressis tandem disruptis vaginatus, superne flexuoso-nutans, bracteis plurimis alternis vagis erecto-patentibus lineari-lanceolatis acuminatis membranaceis pallidis unifloris circumsessus . . . ."

Fig. 2.

Epipogum nutans.

This species agrees with the European *E. aphyllum* in the

entire absence of a root, in the mature state of the plant. And it may at once be stated that *E. nutans* produces on its rhizome numerous hairs which function as root-hairs, as does the European form. To amplify Blume's description, it may be added that large old tubers become hollow by a splitting process taking place in the central ground-tissue. Fig. 2 represents a tuber of size below the average.

All my specimens had inflorescence-axes clearly developed.

Histology of the Rhizome.

(i.) *Scale-leaves* (Pl. VI. fig. 2).

Selecting one of the smaller tubers, which was apparently covered by a brownish felt-work, and displayed no distinct annulation, sections revealed the following appearances:—Outside the rhizome is a densely matted mass of fungal hyphæ, some of which are dead and discoloured. The scale-leaves are broad and completely invest the rhizome. Not only do they completely clothe the rhizome but, except at their apices, they are also so closely pressed against, and adherent to, the axis that on first examination the scales appear as if they were merely the epidermis and a few cortical layers of the axis; and their axillary buds present the appearance of endogenous buds. At this stage the entire epidermis of the axis is adherent to the upper (inner) epidermis of the scale-leaves, so that not only force, but the employment of reagents, such as eau de Javelle, is necessary to separate the two, even in the thinnest sections to be made by hand. No air-containing spaces between this inner epidermis of the scale and the epidermis of the stem could be made out. The outer walls of both of these layers are very thin and cuticularized. Thus the solitary points at which the rhizome communicates directly with the exterior, by cells with walls which are not cuticularized, are the lines of attachment of the scale-leaves. The lower (outer) *epidermis* of the scale-leaf is made up of large cells with thin walls only feebly cuticularized. But very many of these cells grow into enormously *elongated narrow hairs* with thin, non-cuticularized walls, which indubitably *function as root-hairs*. The hairs are coated with particles of humus which cling closely to them, and they are sometimes possessed of short blunt branches (Pl. V. fig. 10). In addition many of the hairs contain fungal hyphæ (Pl. V. fig. 9) which are presumably mycorhizal in nature—for protoplasm is

present in the infected cells of the hairs. In my alcohol-preparations the walls of many of these hairs had split into single spiral ribbon-shaped bands.

Within this epidermis lie 2–3 layers of large parenchymatous cells (mesophyll), which are elongated longitudinally and rather flattened parallel to the surface; this suggests that conduction takes place down the scale-leaf rather than from the outer epidermis to the inner epidermis.

The inner *epidermis* consists of small flattened cells. I failed to detect any vascular bundles within the scales, though leaf-trace bundles run in the rhizome to their bases.

(ii.) *Histology of the Rhizome-axis* (Pl. VI. fig. 1).

The fleshy axis itself is mainly constituted of large parenchymatous cells with very thin walls. Though devoid of starch they contain more or less mucilage, but in the outer layers of the cortex some raphide-mucilage cells occur in addition. In the rhizomes richer in starch, several layers of cells with thin cellulose-walls occupy the position which would normally be taken by a *general* sclerenchyma-*sheath*; they contain numerous grains of starch, and thus clearly mark out a general sheath (Pl. V. fig. 1). The parenchyma-cells immediately round the vascular bundles also contain starch. In the rhizomes from which much starch has been conducted up to the inflorescence-axis there is no accumulation of starch in a general (potential) sheath. This starch, like that in *Monotropa*, does not react typically with iodine-reagents. At first it colours red (varying from a dull red to a red-violet) probably because of the presence of erythrodextrin; with strong iodine the typical blue colour finally appears. Outside the general sheath the layers of cortex are devoid of starch; but the parenchyma around the leaf-trace bundles traversing this region of the cortex contains starch-grains. In the starch-containing cells I could see no trace of mucilage. Thus there appears to be a differentiation into water-storing cells and starch-containing cells. There are but few cortical layers outside the general sheath; thus it is the greatly enlarged stele which makes up the main mass of the swollen rhizome.

Each *vascular bundle* is collateral, and has a well-defined phloëm and xylem. The *phloëm* (Pl. VI. fig. 3; Pl. V. fig. 11) is greatly developed, and consists mainly of elongated parenchyma-cells,

narrower than those composing the greater part of the ground-tissue, but still very broad, considering their location. There are a few sieve-tubes with very distinct calli on the sieve-plates, and narrow companion cells. The *xylem* is not less remarkable; it is made up of large reticulo-spiral tracheïdes (or tracheæ ?) with relatively thin walls, many of them being of extraordinarily wide calibre (Pl. VI. fig. 3).

The small leaf-trace bundles in the cortex are composed of narrow tracheïdes, sieve-tubes, and parenchyma. The sieve-tubes extend nearer to the scale-bases than do the tracheïdes.

The cells comprising the cortical parenchyma just at the point of insertion of the scale, and mesophyll of the scale itself, have markedly pitted walls.

No traces of mycorhizal hyphæ occurred within the axis itself, though the inner epidermis of the scales had conspicuous mycelia. Mycelial masses were absent from scales and axis.

Histology of the Inflorescence-axis.

The axis is hollow at the internodes. The *epidermis* consists of exceedingly elongated narrow cells. No stomata or hairs occur, excepting that at the base of the axis a few hairs are found where the axis commences to be visible between the scale-leaves. The walls are very thin and feebly cuticularized. In the internodes a number (about 25) of *layers of parenchymatous cells* with delicate walls lie within the epidermis, and amongst them are relatively well-developed intercellular spaces. Towards the periphery some of these contain *mucilage* and *raphides*. Only those cells immediately round the vascular bundles possess starch, and then in a small quantity. There is no trace of a general sclerenchyma-sheath. The vascular bundles are disposed in several circles, but the outer layers of the ground-tissue are devoid of bundles. The *phloëm* is well developed, its parenchymatous cells being much narrower than in the rhizome. All the constituents of the phloëm are more protoplasmic and have richer contents than in the rhizome. In comparison with the rhizome, the difference in the *xylem* is most marked. The conducting elements are much reduced in calibre, being represented by a number of very narrow annular and spiral vessels. No pitted tracheïdes occur here or in the rhizome. In each of the inner bundles a lysigenous intercellular space is formed

by the breaking-down of all the vessels save a circle of narrow annular vessels with few widely separated annuli. In the outer bundles this disorganization takes place to a considerably less extent. The bundles have no sheaths of sclerenchyma. Thus there is, as in the rhizome, a complete absence of mechanical tissue; the walls of all the cells are delicate and composed of unmodified cellulose, with the exception of the thin cuticle on the epidermis and the lignified walls of the insignificant bundles of xylem.

Histology of the Scales on the Inflorescence-axis.

I had at my disposal only the portions of the axis below the attachment of the flowers, and hence cannot describe the histology of the bracts. A scale which is above the ground displays the following structure:—It is composed of a lower (outer) *epidermis*, about five layers of *mesophyll*, and an upper (inner) *epidermis*, more or less applied to the axis. The epidermal cells have delicate walls and are longitudinally elongated and narrow—much longer and narrower than those on the subterranean scale. There are neither hairs nor stomata. Cuticle on the outer epidermis is very thin, and is all but imperceptible on the inner epidermis. The elongated cells comprising the mesophyll have tolerably developed intercellular interstices and slender walls; amongst them are numerous larger, elongated, *raphide-mucilage sacs*, which are most abundant close within the outer epidermis. These sacs are more abundant than in corresponding parts of the axis (cf. *Galeola*).

The *vascular bundles* which enter the scales are small and simple, the conducting *xylem* being represented by 2–3 fine annular or spiral vessels, and the *phloëm* being composed of a little mass of parenchyma and very narrow elongated elements, in which I could detect no differentiation into sieve-tubes and companion-cells. No starch occurred in these scales. Again, in the scales there is a complete absence of mechanical tissue. Ascending from the rhizome to the floral region, it will be noted that the scales become narrower and relatively longer. And the transition from the subterranean scales to the aerial ones is histologically a gradual one. At the extreme base of the inflorescence-axis the scales overlap one another and the portions which are overlapped have no hairs, but the free apical parts of these scales have long hairs on which particles of humus cling. On the scales which are inserted upon the aerial part of the axis

the whole of the epidermis is hairless. From this it may be concluded that the *hairs were evolved* (or preserved?) *to act as absorbing organs.*

General Remarks on Epipogum nutans.

The fact that the rhizome-axis is all but perfectly covered by scales, which adhere closely and tenaciously to it, at once suggests that the latter are the absorbing organs of the plant. This view is confirmed when we note that countless long hairs grow out from the exposed epidermis of the scales, also that these hairs penetrate masses of humus which are permeated by fungal hyphæ, and that mycorhizal hyphæ enter the hairs and occupy all the cells of the scales. That the hairs perform their particular functions when the scales are underground, and exposed to the humus, is shown by the gradual manner in which they undergo complete atrophy in scales placed higher up the axis.

The shape of the cells forming the subterranean scales suggests that the substances absorbed by the hairs are transported to the bases of the leaves and thence into the rhizome, and not across the scales straight into the epidermis of the axis. Further evidence for this view is derived from the fact that the leaf-trace bundles may have, even at the bases of the scales, a strong sheath of cells containing starch, whereas no starch occurs in any other parenchyma-cells of the outer cortical layers. On the other hand, we can conclude that the inner epidermis of the scales and the epidermis of the rhizome prevent or retard the inward passage of liquids. Thus these two layers play the part of suberized exodermal cells; and the heavily-pitted cells at the bases of the scales may be compared to the passage-cells of an exodermis. Again, as there appear to be no mycorhizal hyphæ in the axis of the rhizome while there are mycelia in the scales, the latter may physiologically represent the exocortex of the roots of saprophytic orchids (*Galeola, Aphyllorchis, Lecanorchis, Neottia*), or of the axis of the rhizome (*Epipogum aphyllum* and *Corallorhiza innata*).

As the rhizome is drained of its contents by the growing inflorescence-axis, the starch diminishes. It disappears from the general sheath before it deserts the bundles lying within. The parenchyma-cells at the base of each scale acquire slightly thicker walls, which become suberized, and the scales die. The advantage of the suberization of these basal cells when the leaves die is

explicable on the assumption that they prevent the escape of water and the entrance of hurtful fungi.

In the larger and more completely drained rhizomes which I had, no scale-leaves were visible except in fragments, so that their original lines of insertion were visible and caused the annulation described by Blume. In addition, the tuber had become hollow. This may possibly have been the result of the immersion in methylated spirits, but appearances suggested that this hollow condition was occasioned before death, probably because the tubers supplied water to the inflorescence-axis more rapidly than they could absorb it from the soil.

A comparison between *Galeola* and *Epipogum nutans* is instructive.

Both are orchidaceous holosaprophytes. In *Galeola* the subterranean part is mainly constituted of the root-system. There are well-developed succulent roots, which act as the absorbing organs; these are coated for the most part by thick-walled cells, which would at first sight seem incapable of absorbing, and there are only very few stunted broad root-hairs. The scale-leaves possess a peculiar apparatus for storing water, and are primarily organs for getting rid of water. In *Epipogum nutans* there is absolutely no root-system; the subterranean part of the plant is formed solely of a swollen tuber with scale-leaves. The absorbing organs are the scales, which send out innumerable greatly elongated hairs functioning as root-hairs; absorbed water is largely, or entirely, stored up in the water-storing cells of the rhizome, and there is no definite mechanism for getting rid of any excess of water when the plant is not flowering.

Corresponding to the opposite functions of the subterranean scales in the two plants, their structure is very different. And the structure and the contents of the vascular bundles in or going to the scales vary in a like fashion. In *Galeola* there is a huge development of xylem in the scale. In *Epipogum* I could detect no bundles. In *Galeola* the regions of axis near the attachment are devoid of starch, and the leaf-trace bundles have no starch or very little. In *Epipogum* the leaf-trace bundles are markedly clothed with a sheath of starch-containing parenchyma, the starch in which is being conveyed to the central parts.

In *Galeola* and *Epipogum* alike the absorbing organ is enveloped in a sheath of cells containing living fungal hyphæ and no starch (exocortex in *Galeola*, scale-leaves in *Epipogum*).

The conducting xylem, mainly composed of pitted tracheïdes in *Galeola*, is more completely developed in the inflorescence-axis than in the absorbing roots. In *Epipogum* the xylem of the absorbing rhizome is immensely developed and is composed of wide spiral-reticulate tracheïdes (or tracheæ); it is more feebly represented in the inflorescence-axis and, in fact, largely replaced by an intercellular space.

Throughout, the plant *Galeola* is covered by cells with very thick cuticularized walls excepting over the patches on the inner faces of the scales; the intercellular spaces are small; mechanical tissue is greatly developed in the cortex and in the stele. *Galeola* is structurally a xerophyte. Throughout, the plant *Epipogum* is covered by cells with very thin walls, possessing only a thin cuticle or not one at all; the intercellular spaces are large; there is no mechanical tissue whatever. *Epipogum* is structurally a hygrophyte as regards its superterranean parts. This may be due to the habitat (the plant being found in wet dark places), or possibly is associated with the structure of the subterranean parts, *i. e.* the great production of absorbing hairs tends to allow the shoot above ground to be less xerophytic, and the presence of a large water-reservoir further acts in the same direction (compare thin leaves of orchids with pseudo-bulbs).

CORYSANTHES, sp.

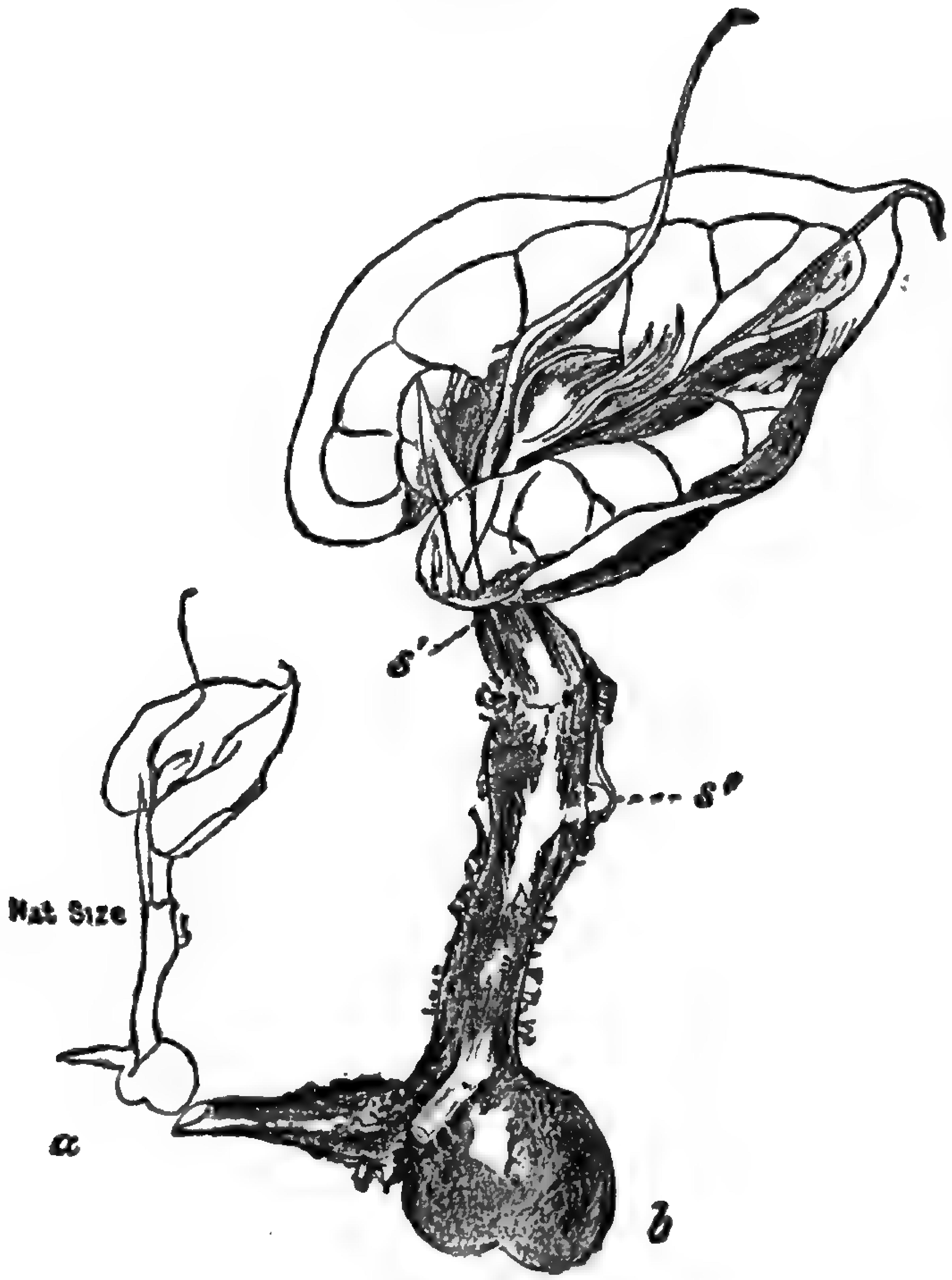
Our knowledge of terrestrial orchids in Europe leads us to infer, as did Reinke, that many green forms growing in substrata rich in humus are hemisaprophytes. Remembering further that holosaprophytes usually are characterized by the possession of colouring-matters,—the presence of a prominent colouring-matter in green terrestrial orchids or the absence of chlorophyll from certain parts of their leaves would cause us strongly to suspect such orchids of hemisaprophytism. In the hope of obtaining some structural evidence of this view, I asked Mr. H. N. Ridley if he would be good enough to send me any Malayan terrestrial orchids which were found growing in a nidus rich in humus and having a habit more or less like *Anæctochilus*. In reply Mr. Ridley kindly sent me a species of *Corysanthes* which he found growing on shaded rocks which were carpeted with moss.

Judging by the habitats of its species, *Corysanthes* seems to be a hemisaprophyte. Blume (7) gives the habitats of three Malayan

species as follows:—*Corysanthes picta* (with a pink colouring-matter): mount Salak in Java, growing in light humous soil, or epiphytic on old and mossy tree-trunks. *C. mucronata*: mount Pangarango in W. Java, growing amongst decaying vegetable remains. *C. fornicata*: mount Salak in Java, on the decaying trunks of trees.

The morphological investigation of the species which I have examined confirms the view that *Corysanthes* is a saprophytic genus.

Fig. 3.



Corysanthes, sp.

Fig. 3 represents the species investigated; and in external form it appears most like *C. picta*. The flowers in the two specimens I had were unopened.

The plant possesses only one foliage-leaf, ovate-cordate, with a fine tapering apex, a conspicuous midrib, two marginal veins and a number of smaller reticulate veins. Below this leaf, on the opposite side of the erect axis, is attached a second leaf (*s'*) in the form of a scale. The axis continues downwards as a vertically descending hairy rhizome. Lower down it, and inserted vertically

below the foliage-leaf, is a second scale (s''), in the axil of which is a well-marked bud. Thus the three leaves have a distichous arrangement. This erect axis at its lower end is attached to a tuberous body which is feebly bilobed and is less hairy than the axis. Near the junction of the tuber and the erect rhizome several (2–3) hairy root-like processes radiate, and arise, from the tuber. So much can be seen with the naked eye.

Histology of the Tuberous Body.

In the tuber there is a regular external layer having its thin walls cuticularized, but with *no stomata.* Many of the cells grow out to form long slender unicellular hairs with cuticularized walls. For the most part fragments of humus do not cling to these hairs, which are not irregular or lobed; but humus adheres to some of the hairs, which are furthermore irregular in contour or even lobed towards their extremities. Straight hyphæ occur in many of the hairs; also hyphæ occur in some of the general cells of the external layer, some of which are discoloured. But no coiled mycorhizal mycelia are found. Beneath the superficial layer is a well-defined *exodermis* (Pl. V. fig. 12), constituted of cells with thin suberized walls. I failed to detect any special passage-cells. Within the *exodermis* succeed about ten layers of cortical parenchyma, the cells of which are large and are crammed with *large* starch-grains. In the centre of the tuber is a disproportionately narrow stele with small vascular bundles. The *endodermis* is thin-walled, and is succeeded by a single layer of pericycle. Typically the stele may be described as triarch, though all sections do not display the same arrangements. There are three small groups of *xylem,* in the form of spiral-reticulate tracheïdes, which dip deeper towards the centre than do the three groups of *phloëm.*

Histology of the Rhizome below the attachment of the Upper Scale.

An *epidermis* with thin cuticularized walls forms the external layer. Amongst the cells are scattered *stomata* which gape open and are normal in appearance.

The surface is raised into many multicellular cylindrical or conical *outgrowths.* The terminal cells of these grow out into usually four or five (4–8) long hairs (Pl. VI. fig. 6). Typically the multicellular outgrowth consists at its base of an axial row of

cells surrounded by five rows of cells (Pl. VI. fig. 7). The superficial cells may decrease in number higher up the protuberance. Clinging to the hairs are particles of humus, around or against which the hairs may coil or flatten themselves. Mycorhizal hyphæ penetrate by means of the hairs, and enter the cortex of the rhizome *viâ* the axial cells of the outgrowth (Pl. VI. fig. 8). By no other channel do the mycorhizal hyphæ penetrate the plants: hence the general epidermal cells contain no hyphæ. The hairs and the superficial cells of the protuberance are feebly cuticularized. Below the lower scale (*s''*) every hair appears to be permeated by mycorhizal hyphæ. Above the lower scale the protuberances are many of them larger, and their hairs are much more elongated, straight, and more slender; these long hairs are not penetrated by hyphæ nor do particles of humus cling to them. At the same level other protuberances are just similar to those described as occurring lower down; they have more irregular broader and shorter hairs containing hyphæ. Here, then, the direct effect of the mycorhizal hyphæ (or of absorbing fluid?) is to shorten and broaden the absorbing hairs. For I assume that these hairs throughout function as root-hairs, since they are intimately associated with particles of humus and with mycorhizal hyphæ.

Within the epidermis succeed about ten layers of *cortical parenchyma*. (There is no trace of an exodermis.) In some spots three to four outer layers of parenchyma contain mycorhizal hyphæ forming typical coiled mycelia (Pl. VI. fig. 8). These cells contain no starch or very little, and the hyphæ can be directly traced from them out to the protuberances. The rest of the cortical cells near the insertion on the tuber contain *small* starch-grains; or some of them are raphide-mucilage cells. The intercellular spaces are of medium size. Ascending towards the scales the starch diminishes.

There is a curious *endodermis*, irregular and with thin walls. The typical dots are to be seen mainly, but not exclusively, on the radial walls of these cells (Pl. VI. fig. 9). Within there is an interrupted layer of *pericycle*. The vascular bundles are abnormal. There is a clear tendency to a radial arrangement, but the bundles of *xylem* are placed nearer the centre of the stele than are the *phloëm*-bundles; and groups of phloëm stand both between and radially outside the bundles of xylem.

The bundles of *xylem* are feebly developed, being represented by about three groups of tracheïdes which have transverse pits

(scalariform-reticulate). In addition there run in the centre of the stele little bundles of very narrow spiral vessels (Pl. VI. fig. 9), which may or may not be connected with the bundles of tracheïdes. In transverse sections some of the spiral vessels are in connection with the tracheïdes: hence it seems probable that they are portions of these bundles which are undergoing atrophy. It is possible, however, that the isolated spiral vessels represent other bundles which have almost disappeared, inasmuch as the bundles of tracheïdes are less numerous than the bundles of phloëm.

The bundles of *phloëm* are better developed. They consist of sieve-tubes, companion cells, and parenchyma. There are three bundles between the groups of xylem, and these are laterally connected with small groups outside the bundles of xylem, so that an incomplete ring of phloëm is formed.

For the rest the stele is composed of parenchyma with thin unmodified walls.

No mechanical tissue exists in the rhizome.

At the base of the rhizome on one side there was, in both my specimens, a minute bud in the axil of a microscopical scale. Below this, at the immediate region of its attachment to the tuber, the rhizome narrows considerably, owing to a diminution in the number of cortical layers. Mycorhizal hyphæ do not pass through this constricted region into the tuber.

Histology of the Radiating Root-like Processes.

Examination at once reveals the fact that these repeat the structure of the rhizome described, and are therefore modified stem-structures. The epidermis has stomata; the multicellular protuberances with their terminal hairs are numerous. The layers of cortex are smaller in number, being most numerous at the proximal end (six layers at most). All these layers, excepting possibly the innermost which lies without the endodermis, contain coiled mycelia. No starch is present in any of the layers excepting in the inner layer when it has no mycorhizal hyphæ. The endodermis and stele are merely small versions of the same structures in the main rhizome. The apices were not perfectly intact, but they were sufficiently preserved to allow the statement that no root-cap was present. At its point of attachment the root-like process becomes constricted like the main rhizome (Pl. VI. fig. 5). At this constricted region the cortical cells form a more or less complete layer of cells with

thick suberized walls. Thus free transport of material to or from the tuber takes place only through the stelar tissue.

Just above the constricted region there is on the upperside a dead, brown scale, otherwise no scales occur in these secondary rhizomes. In the proximal portions some of the cortical cells may have no mycorhizal hyphæ; in the inner layers of the cortex of this region the mycelia have been converted into the well-known refractive masses.

Histology of Axis above the Upper Scale.

The epidermis is smooth. Just above the insertion of the upper scale-leaf the axis is terete, but the stele stands nearer the side on which the scale is attached. And two minute vascular bundles (really meristeles) run vertically upwards on that same side. Higher up two ridges appear in section; thus the stem is raised into two folds. Within each ridge lies one of the two meristeles. Ascending the stem the ridges increase in size and gradually resolve themselves into the margins of the foliage-leaf, and the subjacent meristeles are the two large marginal nerves. Beginning at the level of the upper scale, the central stele commences to show changes in structure. The endodermis has become quite unrecognizable; and the groups of phloëm and xylem as we ascend from this point gradually arrange themselves in a collateral fashion. In particular one bundle becomes marked off, on the side towards the ridges, by two conspicuous medullary rays, from the more closely united mass of 3–4 other bundles.

Where the foliage-leaf is apparently attached to the stem a large bundle runs into the leaf; and the axis above the foliage-leaf has four vascular bundles forming a ring. (In my specimens these 4 bundles were still in an embryonic condition, consisting of a mass of procambium, for the flowers were still in a bud-condition.)

Histology of the Leaves.

The *minute scale-leaf* (s'') consists simply of an outer (lower) and an inner (upper) epidermis and parenchyma-cells. No vascular bundle enters it, nor is a leaf-trace bundle given off to it, though a bundle goes to its axillary bud. No hairs occur on the leaf; the sole function possible to this minute scale-leaf is to protect the bud.

The *larger scale-leaf* (s') is a little more complicated. It is

smooth, has an outer (lower) and an inner epidermis, which are not markedly different from one another, except that a few stomata occur in the outer (lower) epidermis. The mesophyll consists of two to three layers of parenchyma with well-defined intercellular spaces. A few raphide-mucilage cells occur. Only one small vascular bundle enters the leaf and is a rudimentary midrib. At its point of attachment the scale-leaf has on its outer lower face some multicellular hairy protuberances like those on the axis.

The Foliage-Leaf.

The upper epidermis of the foliage-leaf is constituted of very large cells, which have thin walls: they make up between a half and a third of the whole volume of the leaf. So that the upper epidermis appears to form a well-developed water-storing layer; in it there are but few stomata except in the attenuated tip of the leaf. The cells have only a thin cuticle.

The mesophyll, in the thickest part of the leaf, is composed of three layers of cells, amongst which is a considerable system of intercellular spaces. The intercellular spaces are, however, not so large as in the case of a normal spongy parenchyma. There is no trace of a palisade-layer. Towards the margins and apex the mesophyll thins off, finally becoming one cell in thickness. The vascular bundles which run in the mesophyll are typical and are differentiated into xylem and phloëm. A few raphide-mucilage cells occur scattered in the general mesophyll. But at the margins and the acuminate tip of the leaf, these sacs are numerous and may form connected series; in fact the tip is constituted of epidermis, a central vascular bundle with its sheath of nerve-parenchyma, and a mesophyll-sheath mainly represented by raphide-mucilage cells. No starch was visible in the mesophyll, though many chromatophores occurred in its cells.

The lower epidermis consists of cells much smaller than those on the upper face. Many stomata occur amongst its cells, and starch was seen in the guard-cells. A very thin cuticle coats this layer.

General Remarks on Corysanthes.

The rough morphology of this plant, and the histological nature of the vascular bundles in the main axis, both suggest that the foliage-leaf does not supply the whole of the organic food found in the subterranean parts. Probably the plant is

well developed before the foliage-leaf unfolds: thus in *Corysanthes*, as the habit of the genus suggests, we are dealing with a hemisaprophyte. It illustrates the process of atrophy of green foliage-leaves till they become mere microscopical scales devoid of vascular constituents. The stem has become an absorbing organ, and developed entirely peculiar structures, before the plant has lost its chlorophyll. In particular this appears to show that we are not entitled to speak of degenerating effects of the loss of chlorophyll in holosaprophytes and holoparasites, for these changes commence before the loss of chlorophyll. It seems more correct to speak of the degrading effect of the absorption of organic matter, and to look upon the disappearance of the chlorophyll as one of the many structural simplifications.

As regards the tuber, the histological nature of the superficial layer and exodermis, the frequent absence of particles of humus from the hairs and the doubtful occurrence of mycorhizal hyphæ in them—all these facts associated with the fact that the starch-grains in the tuber are large, not transitory small grains—suggest that the tuber is an organ especially adapted for the storage of food, particularly of carbohydrates, and that it is, at most, only secondarily an absorptive organ. Further, it seems probable that the hairs, at any rate later in life, function as anchoring-threads * rather than as absorbing-cells.

From analogy with *Epipogum nutans* and *Dictyostegia orobanchoides*, it might be thought that the multicellular protuberances, with their hairs, represented reduced leaves. This view is negatived by their irregular arrangement: by their occurrence on parts above the insertion of the reduced leaves, and even on the base of the one leaf: and finally by the contrast between the structure of the smallest scale—quite smooth and hairless—and themselves. The distribution of the protuberances with their hairs makes it highly probable that *they are peculiar structures which were specially evolved to absorb nutrient material.*

SPIRANTHES AUSTRALIS, *Lindl.*

Judging *Spiranthes australis* by its relatives, it seems probable that the plant is hemisaprophytic. And this hypothesis is

* This passage was written before I heard from Mr. Ridley the habitat of this *Corysanthes*, but I judged from the structure of the hairs on the tuber that the plant grew on a hard solid substratum to which it was anchored by the hairs. Mr. Ridley found the plant growing on rocks.

strengthened on remembering the habitat of the plant. I found hundreds of individuals dotting the hill-sides on Dane's Island, Whampoa; all of them grew in black humous soil. Still there is a large leaf-surface, so I thought it might be worth examination.

Roots.

The roots are tolerably succulent. Outside is a persistent *piliferous layer* of one layer of cells, the outer walls of which are feebly cuticularized. The walls are marked with *reticulate cellulose-thickenings* which run in a direction at right angles to the axis of the root. Some of the cells grow out into very long slender *root-hairs.* Mycorhizal hyphæ penetrate by means of these hairs, and by them alone. Within is a typical *exodermis* with thin suberized walls and passage-cells. It is succeeded by about ten layers of cortical parenchyma, in some of the outer layers of which mycelia occur. Starch was found in all the cells excepting those infected with mycorhizal hyphæ, and excepting the raphide-mucilage cells. A thin-walled endodermis and a polyarch stele with an interrupted pericycle complete the structure.

Scape.

The scape is long and slender, and has only small bracts; it is almost as dependent on the purely vegetative part of the plant as is the scape of a holosaprophyte. Hence it differs from the latter only in the more numerous stomata and the larger intercellular spaces of the four-layered cortex.

General Summary on the Morphology and Physiology * *of Orchidaceous Saprophytes.*

1. The first general characteristic is the *relatively large development of subterranean parts of the plant, and the dwindling of the parts protruding into the air.* The food comes solely from the substratum and is entirely absorbed by organs lying in it. No nutriment is taken in by the aerial parts. A saprophyte may be compared to a submerged water-plant which has preserved its ancestral mode of producing flowers protruding into

* As all the physiological conclusions in this paper are drawn from analogy and from morphological observations, they must be regarded as tentative.

the air. In the holosaprophyte the flower-bearing axes alone emerge from the nidus in which the plant rests. Even in *Corysanthes* one sees that the major portion of the plant is concealed in the mass of decaying vegetable matter in which it grows; only one foliage-leaf and a flower are freely exposed to the light. In a later paper I shall show that in green *Burmannias* there is an analogous peculiarity.

2. The next point of interest concerns *the different modes in which absorbing-organs are formed*, and their various shapes. In some forms the roots alone (or almost alone) absorb (*Galeola javanica, Lecanorchis malaccensis, Aphyllorchis pallida*). In others it is the subterranean parts of the shoot which take in nutritive solutions; whilst the root-system is absent (*Epipogum, Corallorhiza*, or may (?) be represented by an organ mainly functioning as a food-reservoir (tuber of *Corysanthes*).

The *form* of the *absorbing-roots* varies considerably. *Galeola javanica* has a close tuft of relatively short, thick, fleshy, unbranched roots which are inserted on a small rhizome. *Lecanorchis malaccensis* and *Aphyllorchis pallida* have longer, more slender, feebly branched or unbranched roots which are attached to an elongated straight rhizome.

The *histology* of the *external layers of the absorbing roots* also displays considerable differences in the several plants. In *Galeola javanica* an irregular covering of cells with thick suberized walls coats the roots; the development of root-hairs is reduced to a minimum the few hairs present being short and broad. *Aphyllorchis pallida* has more numerous root-hairs, which are furthermore normal in shape. On the other hand, *Lecanorchis malaccensis* possesses a persistent external layer (corresponding to the piliferous layer) which is hairless but assumes the form of a modified velamen. It is interesting to note that in the terrestrial green orchid *Spiranthes australis* the roots have a persistent piliferous layer, some of the cells of which grow out into very long root-hairs, whilst others have their external walls cuticularized and their lateral and inner walls marked with reticulate thickenings of cellulose. The roots of *Spiranthes* and *Lecanorchis* seem to show that in Orchidaceæ the evolution of the velamen was not a matter of great difficulty; for it is foreshadowed in these terrestrial plants.

Usually in holosaprophytes there is a dwindling of root-hairs on roots (*see* Johow, cited on p. 213); it is otherwise with *absorbing-*

rhizomes, for in them there is an extensive development of hairs which function as absorbing-cells. In *Epipogum nutans* the rhizome-axis is smooth and does not absorb: it is covered by relatively large scale-leaves which take in the food, and for this purpose produce a great number of greatly elongated narrow hairs (compare *Dictyostegia orobanchoides*). On the other hand, in the green *Corysanthes* sp. the (2–3) subterranean scale-leaves are small and smooth and do not take in the food; but the axis bears numerous absorbing-hairs perched upon multicellular outgrowths. Similar outgrowths occur on the rhizome of *Corallorhiza innata*. *Epipogum aphyllum* contrasts with *Epipogum nutans* in that, in the former, the axis produces the absorbing hairs, and the transitory leaves are smooth.

Concerning the *absorbing-organs* of orchidaceous saprophytes, three features are noticeable:—(i.) that they *lie in the superficial layers of the substratum*; (ii.) that *their volume is increased relatively to the surface* (compared with typical roots of ordinary plants); (iii.) that the *absorbing-cells, including hairs, function for a long time*, and do not die speedily as do the root-hairs of normal terrestrial plants. The object of these arrangements is tolerably obvious. The humus-giving bodies are present in greatest quantity at the surface of the substratum and in the layers immediately below. Hence the absorbing-system will live in these upper layers. In addition, new supplies of food come constantly from above. Thus there is no need for the manufacture of new absorbing-organs to penetrate into and exhaust deeper regions of the soil; the old feebly-branched roots or rhizomes and the old absorbing-cells are all that are required, because the food comes to them.

Essentially connected with the absorbing-organs are the mycorhizal hyphæ, which are present in all known saprophytes (excepting *Wullschlægelia*, according to Johow). The function of mycorhiza is still a mystery. All that is known is that certain plants have on or in their roots mycorhizal hyphæ; that mycorhiza is absent from roots growing in soils devoid of humus; and that in the case of endotrophic mycorhiza the fungus does not kill the protoplasm of the cells in which it dwells. But these facts do not entitle us to assume that the fungus exerts a beneficial effect on its host; and Frank's observations (on Beeches and Conifers) are too meagre and uncritical to be considered as proving anything. Still the distribution of the hyphæ (9) in

holosaprophytes appears to confirm the theory that mycorhizal hyphæ exert a beneficial effect on the host, and that the fungus is not merely a passive companion. *The mycorhizal fungus makes its way into parts which are absorbing*, whether the latter be rhizomes or roots; further, it avoids the rhizome (including subterranean scale-leaves) if the latter does not absorb food, though the walls of the cells may be as thin or even thinner than those of the absorbing-organ. *Galeola javanica* and *Epipogum nutans* afford good examples of this. In *Galeola* the mycorhizal fungus penetrates the roots and small parts of the rhizome-axis which have hairs; but it does not live in the scale-leaves, although the cell-walls of the latter are very thin in places. In *Epipogum nutans* the fungus does penetrate the scale-leaves, and roots are absent. In *Galeola* the scale-leaves do not absorb food; in *Epipogum nutans* they are the only absorbing-organs possessed by the plant. Again, in *Corysanthes* hyphæ enter and live in the absorbing rhizome-axis, but not in the delicate scale-leaves. In *Aphyllorchis* and *Lecanorchis*, too, the roots, but not the subterranean scales, have mycorhizal mycelia. In particular *mycorhizal hyphæ appear to enter the plant only by cells which are specifically absorbing-cells.* In *Galeola javanica* they enter by any of the superficial cells; in *Epipogum nutans* only by the long hairs of the absorbing-scales; and more markedly in the rhizome of *Corysanthes* sp. only the hairs on the multicellular protuberances permit the entrance of hyphæ; and where these are absent, *i.e.* higher up the axis, no mycelia occur in the rhizome. Again, in the green *Spiranthes australis*, in my material, hyphæ entered only through the root-hairs, not by the ordinary cells of piliferous layer. Therefore it seems probable that the absorbing-cells exert some chemotropic power of attraction on the mycorhizal hyphæ.

One important point suggesting that the mycorhizal fungus exerts a beneficial effect on the host is that in *the cortical cells infected by mycorhizal mycelia the nuclei grow and become much more deeply-staining.* In fact, the nuclei of the cells infected with the hyphæ remind one of the hyperchromatic nuclei in certain vigorously absorbing-cells of animal tumours.

Finally, in confirmation of the view that the mycorhizal fungus is no passive companion, there is the fact that no reserve-foods are stored up in cortical cells which contain active mycelia. Thus in these infected cells no starch is present, even when it is

largely stored in the adjoining cells. But this fact might be interpreted in many different ways.

The next point in the histology of the absorbing-organs is the *large size of the cortex and the smallness of the central cylinder* (excepting *Epipogum nutans*). These organs have usually to act as food-reservoirs till the inflorescence-axis shoots up and the stock of food demanded. In the plants investigated there is a tendency for the outer layers of the cortex to entertain, throughout life, active mycorhizal mycelia and to form a distinct *exocortex* (roots of *Galeola*, *Aphyllorchis*, *Lecanorchis*, *Neottia* (according to Drude); rhizomes of *Epipogum aphyllum* and *Corallorhiza innata*). This layer is represented in *Epipogum nutans* by the adpressed scales coating the rhizome. In the young stages the active mycelia descend into the deeper layers of the cortex, and may even reach the endodermis. Usually these mycorhizal hyphæ which lie more deeply are soon converted into inert highly refractive masses. The cortical tissue within the exocortex is characterized by being a receptacle for the storage of food (starch); and it may be differentiated into a *mediocortex* and an *endocortex*, the latter of which is never penetrated by the mycorhizal fungus (*e. g.*, roots of *Galeola*, rhizomes of *Epipogum aphyllum*, *Corallorhiza innata*). Only in one case was there any indication of the solution of the dead mycelial masses, namely, in *Lecanorchis*. The *structure* of the *central cylinder* of the roots is normal, excepting that there is a tendency for the conducting constituents of the xylem to dwindle. In absorbing-rhizomes the central cylinder, even in *Corysanthes*, tends to become root-like in appearance, and the xylem is very reduced. We can possibly associate the reduction of the vessels with the fact that absorption takes place at all regions of the absorbing structure (not merely near the apex), and can compare this with the reduction in such epiphytes as *Aeranthus* and *Tillandsia usneoides*, or with submerged aquatic plants.

In *Epipogum nutans*, on the other hand, the cortex is small and devoid of mycorhizal hyphæ. The stele is large and the conducting elements of the xylem greatly developed.

Structure of rhizomes which do not absorb solutions.—As there appears to be no mechanism by which the roots rid themselves of the excess of water absorbed, and as the nutrient substances must be conveyed sooner or later into, or through, the rhizome, it seems *a priori* probable that most of water absorbed by all

the roots passes into the rhizome. This would lead us to anticipate that there would be a relative increase in the number of the conducting elements of the xylem in the rhizome. And such is the case. This goodly development of xylem does not occur in the absorbing-rhizome of *Corysanthes*, for the reason given above, and probably also because stomata permit the excess of water to be given off. The xylem of the tuber of *Epipogum nutans* is well developed because the tuber stores water instead of giving it off through stomata.

In *subterranean parts of the saprophytes investigated there appears to be a very distinct mechanism to enable the plant to rid itself of any excess of water.* In *Lecanorchis*, *Aphyllorchis*, and *Corysanthes* stomata occur on the subterranean axis and on the scales and are widely open (in alcohol specimens). In *Lecanorchis* there is, in addition, a hypodermal system of storage-tracheïdes in the scales. In *Galeola javanica* there are no stomata; but water can pass out through certain patches on the leaves when the epidermal walls are thin; under these patches there is an extensive hypodermal system of storage-tracheïdes.

It is quite possible that in the holosaprophytes the stomata have another function, *i. e.* of assisting in the interchange of gases involved in respiration.

Structure of the floral axis of Lecanorchis, Aphyllorchis, *and* Galeola.—The axis bears only a few and widely separate scales on its aerial part. Compared with the subterranean parts, the scales are fewer, smaller, and are not so long-lived. The axis is coated with an epidermis possessing thickly cuticularized outer walls; hence transpiration is slight. Many scapes of green orchids are very similar except for the thin green cortex, and are mainly conducting structures. So we shall not expect the structure of these axes to be very dissimilar to that of a green scape: in fact we find that it is not so. The only difference lies in the greater number of stomata and the larger intercellular spaces in the green cortex (*Spiranthes*). In the holosaprophytes there is the typical general sclerenchyma-sheath, ordinary collateral bundles with protoxylem in the form of spiral or annular vessels.

Epipogum nutans is as distinct in the structure of its floral axis as it is with regard to its rhizome. Its habitat—in marshy, moist, shaded regions—is reflected in its structure. Large intercellular spaces are in the ground-tissue and xylem. The conducting constituents of the xylem are narrow spiral or annular

vessels. There is no mechanical tissue, and the walls of all the cells are thin and unmodified cellulose (excepting xylem and feeble cuticle).

No stomata occur in *Epipogum nutans* or in *Galeola javanica*.

Vascular Bundles of Holosaprophytes.

Hitherto in holosaprophytic monocotyledons a normal complete vascular bundle has been described by Poulsen alone as occurring (in *Sciaphila*). Statements as to the simplicity of the bundles are contained in the works of Johow and Reinke. And, as far as I know, amongst dicotyledonous holosaprophytes, only F. W. Oliver (8) has given an account of a complete typical vascular bundle (in *Sarcodes*).

Yet in the holosaprophytic orchids on which I have worked there is in the vascular bundles *always a clear distinction into xylem and phloëm.* As regards the *xylem*, it is quite typical in the floral axis, but is more feebly developed in the roots, where no spiral or annular vessels occur. There appears to be a tendency to form tracheïdes with transverse narrow pits, in place of forming vessels with round pits or other modes of thickening. This is an interesting point, in that the wood thus *displays a structure more primitive in both an ontogenetic and a phylogenetic sense.* In all cases the *phloëm* is highly differentiated throughout the plant (except in the finer bundles of the scales), and possesses sieve-tubes, companion cells, and parenchyma. The general peculiarity is that the parenchyma is more developed, and the sieve-tubes are smaller and fewer than in a typical bundle. This, again, is a more primitive condition.

Degeneration in the Shoot.

As a saprophyte gives up its autotrophic mode of nutrition, it is the leaves which in particular lose their great importance as organs of nutrition. And we shall expect that they will display more complete phenomena of degeneration and change than any other parts of the plant. Such, in fact, is the case. The *leaves of holosaprophytes are reduced to mere simple scales.*

It has been noted by Darwin that when an organ is undergoing atrophy, it is liable to vary through much wider limits than is the case with an ordinary organ. If, then, considerable variation be of any assistance in hastening the evolution of an organ, we might anticipate that a degenerating organ would

rapidly and easily assume a new form and take on fresh functions. This anticipation holds, at any rate, for the shoots of holosaprophytes, and in particular for the leaves. This may be illustrated by a brief recapitulation of the *functions and structure of the subterranean scales* of the holosaprophytic orchids investigated and of *Corysanthes.*

(i.) *Absorbing-organs.*—Thin cell-walls, numerous long absorbing-hairs, no stomata, no vascular bundles, but have leaf-trace bundles: mycorhizal hyphæ present, e. g. *Epipogum nutans.*

(ii.) *Transpiring* or *Water-excreting Organs.*—No mycorhizal hyphæ: well cuticularized epidermis. Vascular bundles.

(*a*) Stomata: no hypodermal system of tracheïdes. *Aphyllorchis pallida.*

(β) Stomata: a small hypodermal system of tracheïdes. *Lecanorchis malaccensis.*

(γ) No stomata: thin-walled patches of epidermis: a large hypodermal system of tracheïdes. *Galeola javanica.*

(iii.) *Functionless*, or merely temporary, bud-protectors.

The lowest scale of *Corysanthes* has few stomata, no vascular bundle, and no leaf-trace goes towards it. The large scale higher up is larger, and has stomata and one vascular bundle. It is interesting to note that in *Corysanthes* the leaf-trace bundles and bundles within the scales have disappeared before the scales have been suppressed. This fact would seem to imply that leaves can entirely disappear in time without leaving any indications of their former presence; not only in flowers but also in vegetative parts.

Attention has already been directed to the histology of the vascular bundles of the shoot. It is, however, worthy of note that the plant which in the series investigated possesses the most reduced leaves and simplified vascular bundles is the hemisaprophyte *Corysanthes.* This suggests that it is not the lack of chlorophyll which is most potent in inducing the structural modifications in holosaprophytes, but that *it is the habit of absorbing organic material which initiates the morphological changes*: and one of these induced changes is the gradual disappearance of the chlorophyll. Amongst parasites the dwindling of the leaves is not necessarily associated with the loss of chlorophyll. There are a number of green parasitic genera in the Loranthaceæ and Santalaceæ which have species with normal foliage, and other species with tiny scales. The parasitic *Cassytha* has vivid green stems, but only minute scale-leaves. Many green autotrophic plants

exhibit the same regular atrophy of the leaves (*Asparagus*, *Ruscus*, *Muehlenbeckia*). The converse proposition, however, does hold that where the chlorophyll disappears the leaves are small and simple.

In conclusion, I take the opportunity of expressing my warmest thanks to Mr. H. N. Ridley and Professor A. F. W. Schimper for material they were good enough to give me; to Mr. A. H. Church (Oxford) for the drawings of the whole plants; and, finally, to Professor Vines for his kindness in permitting me to use the Botanical Laboratory at Oxford.

Botanic Gardens, Oxford, Dec. 1894.

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EXPLANATION OF THE PLATES.

Abbreviations.

cx.=cortex. *endo.*=endodermis. *ep.*=epidermis. *u.ep.*=epidermis of the upper face of a leaf. *l.ep.*=epidermis of the lower face of a leaf. *ex.*=exodermis. *m.* = mucilage-cell. *mt.p.* = multicellular protuberance. *my.*= mycorhizal hyphæ. *my.m.*= mycelial mass. *my.p.*= mycelial pegs. *pc.*=pericycle. *pi.l.*=piliferous layer. *pl.*=placenta. *ph.*=phloëm. *p.ph.*=protophloëm. *ph.s.*=sieve-tube. *ph.s.c.*=callus on sieve-plate. *ps.*=passage-cell. *r.m.*= raphide-mucilage cell. *sc.*=sclerenchyma. *sh.*=sheath. *g.sh.*=general sheath. *b.sh.*=sheath round one bundle. *sp.*=spiral vessel. *su.l.*=outermost layer of cortex with suberized walls. *tr.*=tracheïde. *xy.*=xylem. *xy.an.*=annular vessel.

Plate IV.

Fig. 1. *Galeola javanica.* Transverse section of root, near the base, showing the outer layers. (Leitz 1. 7, reduced to 2/5.)

2. Ditto. Transverse section of root, showing a single layer of sclerenchyma lying outside the endodermis and interrupted by passage-cells opposite the xylem; also shows two bundles of phloëm. (Leitz 1. 7, reduced to 1/2.)

3. Ditto. Transverse section of a vascular bundle and part of the general sheath of the scape. (Zeiss 3. D, reduced to 1/2.)

4. Ditto. Transverse section of part of a bract. (Zeiss 3. A.)

5. Ditto. Transverse section of part of a subterranean scale. (Zeiss 3. A.)

6. Ditto. Transverse section of part of placenta showing two mucilage-cells and portion of a third, also parenchyma devoid of starch. (Zeiss 1. D, reduced to 1/3.)

Plate V.

Fig. 1. *Aphyllorchis pallida.* Transverse section of part of root, showing one bundle of xylem and two of phloëm. (Zeiss Apo. 8 mm., Comp. Oc. 8, reduced to 1/2.)

2. Ditto. Transverse section of vascular bundle of scape. (Zeiss 3. D, reduced to 1/3.)

3 *a*, *b*, *c*, *d*. Ditto. Surface-view of stomata of leaf. (Zeiss 3. D.)

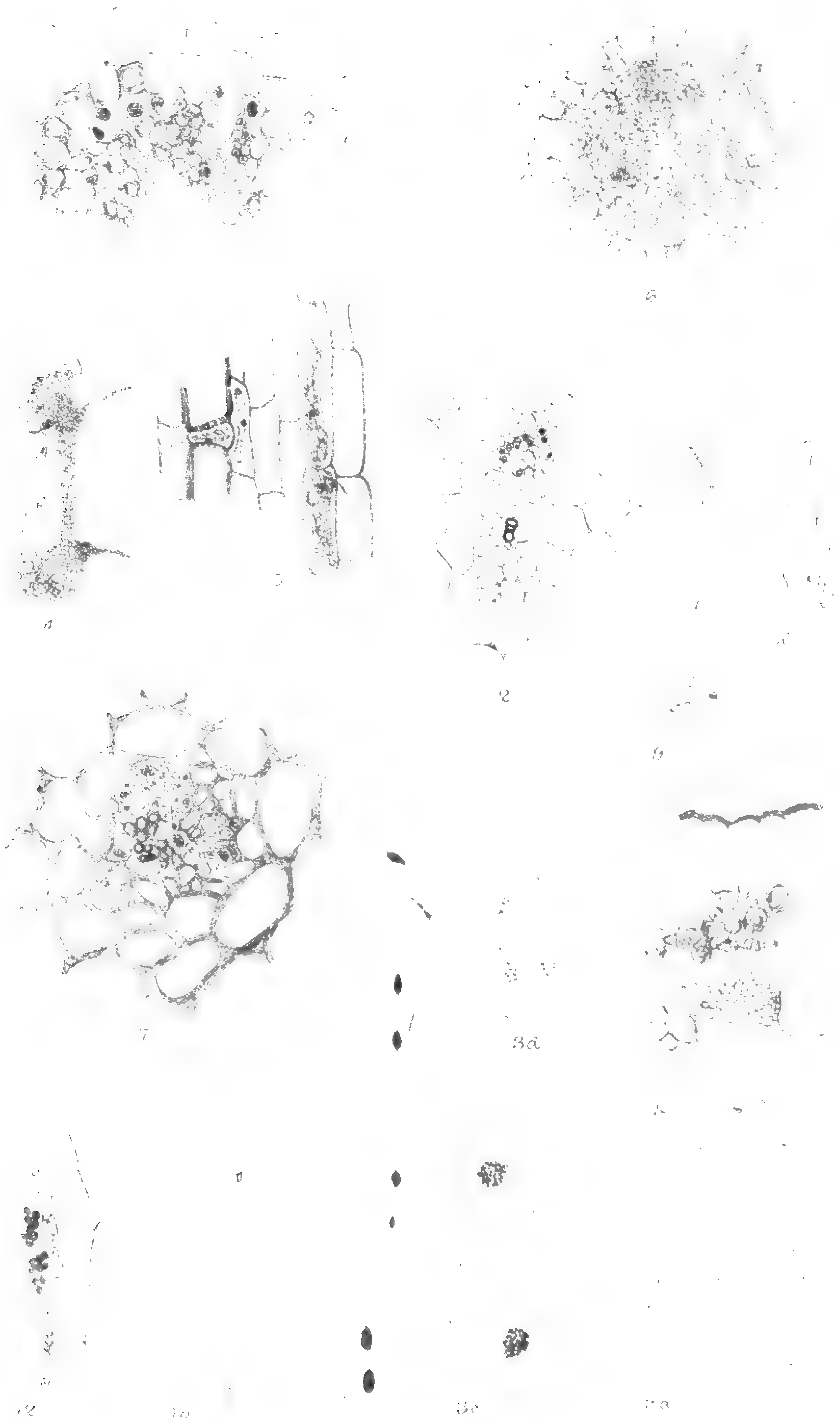
4. Ditto. Transverse section of ovary-wall. Dots represent starch. (Zeiss 1. A.)

5. *Lecanorchis malaccensis.* Longitudinal section of outer portion of root. (Zeiss Apo. 8 mm., Comp. Oc. 8, reduced to 1/3.)

6. Ditto. Transverse section of stele of root. (Zeiss Apo. 8 mm., Comp. Oc. 4, reduced to 1/2.)

7. Ditto. Transverse section of an incompletely collateral bundle from base of scape. The arrow points radially outwards. (Zeiss 3. D, reduced to 1/2.)

HISTOLOGY OF GALEOLA.



P.G. del. ? Morgan lith.

HISTOLOGY OF APHYLLORCHIS, ...

... IM, AND COPYSAN...

P. G. del.
R. Morgan lith.

West Newman imp.

HISTOLOGY OF EPIPOGUM AND CORYSANTHES

PLATE V. (*continued*).

Fig. 8. Ditto. Transverse section of part of scape, including one vascular bundle. (Zeiss 3. DD, reduced to $\frac{2}{3}$.)

9. *Epipogum nutans.* An absorbing hair with hyphæ, from subterranean scale-leaf. (Zeiss 2. DD, reduced to $\frac{1}{4}$.)

10. Ditto. Lobed end of an absorbing hair. (Zeiss 3. D, reduced to $\frac{1}{4}$.)

11. Ditto. Sieve-tubes, showing callus on sieve-plates. (Zeiss 3. DD, reduced to $\frac{1}{3}$.)

12. *Corysanthes.* Section of outer layers of tuber. (Zeiss, Apo. 16 mm., Comp. Oc. 8, reduced to $\frac{1}{3}$.)

PLATE VI.

Fig. 1. *Epipogum nutans.* Transverse section of tuber. (About natural size.)

2. Ditto. Longitudinal section through outer part of tube, showing the attachment of one hairy scale and the upper decaying end of another. The dots denote starch. (Highly magnified.)

3. Ditto. Transverse section of a vascular bundle of tuber. The dark patches in the phloëm denote callus on sieve-plates. (Zeiss 1. DD, reduced to $\frac{1}{2}$.)

4. Ditto. Transverse section of vascular bundle of scape. The arrow points radially inwards. (Highly magnified.)

5. *Corysanthes.* Longitudinal section through top part of tuber (*tu.*) showing the base of the main flowering-axis (*m.a.*) and the attachment of a root-like process (*rh.p.*) or rhizome-branch. (Magnification about 2.)

6. Ditto. A multicellular outgrowth from the base of the main flowering-axis. (Leitz O. 3.)

7. Ditto. Transverse section through the basal part of a multicellular outgrowth. (Zeiss 3. D.)

8. Ditto. Longitudinal section through the outer layers of the base of the main flowering-axis, showing mycorhizal mycelia and the base of a multicellular outgrowth. (Zeiss 2. DD, reduced to $\frac{1}{2}$.)

9. Ditto. Transverse section of stele of the main flowering-axis near its base. (Zeiss, Apo. 8 mm., Comp. Oc. 8, reduced to $\frac{1}{2}$.)

On some Variations in the Number of Stamens and Carpels. By I. H. Burkill, B.A., F.L.S., Gonville and Caius College, Cambridge.

[Read 17th January, 1895.]

The capability of varying is admittedly a general property of all living organisms; but of how variation is affected by forces other than natural selection we know but little. In beginning this series of observations, commenced at the suggestion of Mr. J. C. Willis, I have had in view principally the object of ascertaining why stamens and carpels are often reduced in number. The literature bearing on this subject is much scattered, and principally turns upon the question of unfavourable conditions causing the total—*not* partial—disappearance of the andrœcium or gynœcium. To what degree do we understand how conditions affect the sexual organs in the individual, not the race? The elaborate experiments of H. Hoffmann[1], F. Heyer[2], C. Fisch[3], and Düsing[4] on the sex of the Hemp, and of Heyer[5] on *Mercurialis annua*, have shown that here, for any variety, the proportion of male to female plants is the same under all conditions. Clos[6], too, says that dwarfing does not affect the sex of the plant; in other words, the sex is, as Heyer says, present in the seed. But, on the other hand, Forsberg[7] finds that the sex of the Juniper is influenced by the nature of the place in which it grows—the more inclement the spot, the greater the percentage of male plants. A similar result Hoffmann[8] gets with *Spinacia*, *Lychnis*

[1] "Rückblick auf meine Variations-Versuche von 1855–1880." Bot. Zeitung, xxxix. p. 381 (1881).

[2] "Das Zahlenverhältniss d. Geschlechter." Deutsche landwirt. Presse, xiii. 1886, p. 163; *fide* Just's Jahresbericht, 1886, p. 814.

[3] "Ueber die Zahlenverhältnisse d. Geschlechter beim Hanf." Berichte d. deutschen bot. Gesellschaft, v. p. 136 (1887).

[4] "Die experimentale Prüfung d. Theorie v. d. Regulierung d. Geschlechtsverhältnisses." Jenaische Zeitschrift, xix. p. 108 (1885).

[5] "Untersuchungen ü. d. Verhältniss d. Geschlechtes bei einhäusigen u. zweihäusigen Pflanzen." Inaug. Diss. Halle, 1883. Reviewed, Bot. Centralblatt, xv. p. 5.

[6] "Du nanisme dans le règne végétal." Mém. Acad. Toulouse, 9me série, i. p. 391 (1889).

[7] "Ueber d. Geschlechtsvertheilung bei Juniperus communis." Bot. Centralblatt, xxxiii. p. 91 (1888).

[8] "Ueber Sexualität." Bot. Zeitung, 1885, xliii. p. 145.

vespertina, Sibth., *Rumex Acetosella*, Linn., &c. Meehan[9] observes that severe competition causes in *Ambrosia artemisifolia*, Linn., the proportion of male plants to be increased. Such observations, parallelled by those of Prantl, Borodin and Magnus on starved prothalli, and of Klein on *Volvox*, show that in many cases the sex in diœcious plants is influenced by external conditions.

Again, when, as abnormalities, female or hermaphrodite flowers appear on male or female plants, these generally occupy definite positions, showing that some influence is at work. Thus in *Salices* they are usually confined to the upper or the lower extremity of the catkin; and in the Hazel (*Corylus Avellana*, Linn.), when hermaphrodite flowers appear on the female catkin, or female flowers on the male catkin, they are at the base[10]. Many similar cases might be given, showing that in abnormal cases of monœcism in diœcious plants, as a rule, the abnormal flowers occupy a definite position, and are not scattered irregularly anywhere on the plants. In fact, the appearance of such a plant as *Typha* or *Arum*, where the male flowers are always fixed in position with regard to the female, is repeated in the abnormal cases quoted, showing that probably the position is due to definite causes, and not to spasmodic variation, such as Meehan terms "variety for mere variety's sake"[11].

Now passing from this to gynodiœcism and gynomonœcism, we have evidence that active influences exist which, if not causing, determine in some degree the extent of them. Willis[12] has suggested that nutrition is a determining factor in the gynodiœcism of *Origanum vulgare*, Linn. Warming[13] accounts for the gynodiœcism of the Caryophyllaceæ as due to the same cause. Ludwig explains it in *Erodium*[14] as caused by unfavourable conditions, and as due to deficient nourishment, which in *Cerastium*

[9] "Changes of Flowers normally of one Sex to the other." Proc. Acad. Nat. Sci. Philadelphia, 1880, p. 353.

[10] For the literature relating to this, *cf.* Penzig, 'Pflanzen-teratologie, Genoa, 1892–94.

[11] "Contributions to the Life-Histories of Plants. No. II." Proc. Acad. Nat. Sci. Philadelphia, 1888, p. 282.

[12] "On Gynodiœcism in the Labiatæ" (2nd paper). Proc. Camb. Phil. Soc. viii. p. 17 (1892).

[13] "Om Caryophyllaceernes Blomster." Festskrift Bot. Foren. p. 194 (1890); *fide* Just's Jahresbericht, 1890, p. 530.

[14] "Die Gynodioecie v. *Digitalis ambigua*, Murr., u. *D. purpurea*, L." Kosmos, 1885, xvi. p. 107.

perfoliatum is dependent on the time of the flowering period of the plant, and in *Hyoscyamus niger*, Linn., b. *agrestis*, Veit.[15], is dependent on the position of the flower. Raunkjaer[16] observes that female flowers on *Scabiosa succisa*, L., are more common in Denmark than in Würtemberg.

Androdiœcism and andromonœcism are attributable to similar causes. Hermann Müller[17] observed the abortion of the carpels in the Alps, and attributes it to insufficient nutrition.

But now coming to cases where the sexual organs of both sexes are present, but vary in number, we find very little information. Changes in the proportion of stamens to carpels have been noted in *Stratiotes* to have some relation to climate. Goethardt[18] has observed in *Pavonia* that plants of warmer localities have more stamens in their flowers than those of colder places; but this characteristic exhibited a tendency to inheritance. For in seed grown at Göttingen, obtained from Breslau, Leipzig, Buda-Pest, and Palermo, the following average numbers of stamens were obtained:—25·25, 29, 30·4, and 32·1 respectively. Beyond this there are but few facts recorded; and the observations contained in this paper were commenced with a view to fill in part this gap in our knowledge. It is obvious that they have considerable bearing upon questions connected with gyno- and andro-diœcism and -monœcism, and on the origin of diœcism and diclinism.

From the observations of many observers, cleistogamy is caused by the following influences:—according to Warming[19], by cold (Caryophyllaceæ); to J. Scott[20] (Acanthaceæ), Michalet[21] (*Viola*), Torrey and Gray[22] (*Helianthemum*), and Hoffmann[23] (*Papaver*), by poor soil; to Eggers[24], by unfavourable atmospheric

[15] "Weitere biologische Mittheilungen." Bot. Centralblatt, viii. p. 89 (1881).

[16] "Nogle Jagttagelser over Planter med forskjelligformede Blomster." Bot. Tidsskrift, xvii. p. 238; *fide* Just's Jahresbericht, 1889, p. 554.

[17] "Die Variabilität d. Alpenblumen." Kosmos, vii. p. 441 (1880).

[18] "Beiträge zur Kenntniss d. Malvaceen-Androecium." Bot. Zeitung, xlviii. p. 390 (1890).

[19] *Loc. cit.*

[20] "Dimorphism in *Eranthemum*." Journ. of Bot. x. 1872, p. 161.

[21] "Sur la Floraison des Viola de la Section Nomimium, de l'*Oxalis acetosella* et du *Linaria spuria*." Bull. Soc. Bot. de France, vii. 1860, p. 465.

[22] A Flora of North America, vol. i. p. 151. New York, 1838–40.

[23] "Culturversuche ü. Variation." Bot. Zeitung, xlii. p. 226 (1884).

[24] "Kleistogamie einiger West-indischer Pflanzen." Bot. Centralblatt, viii. p. 57 (1881).

conditions; to Bennett[25] (*Stellaria*), Ludwig[26] and Vöchting[27], by want of light; to Graebner[28], by unsuitable relationships of light to temperature; and, according to Ludwig[29], in *Collomia grandiflora* it is the apical flowers which are cleistogamic. Further, there are many well-known cases in which cleistogamic flowers regularly precede or follow chasmogamic flowers on the same plant. Do such influences affect the number of sexual organs in a flower? It is very probable; for is not cleistogamy often associated with reduction in the sexual organs, and reduction in the corolla associated both with cleistogamy and with abortion of one sex in gyno- or andro-diœcism? Further experiments, it is hoped, will throw more light on this question.

STELLARIA MEDIA, *Cyr.*

The number of stamens in this plant is known to be very variable. A glance at Table I. will show that every possible number of perfect stamens, from 0 to 10, was found among the 5684 flowers recorded in it. Chasmogamic and cleistogamic flowers are not distinguished from each other in it.

Plants growing under different conditions were examined. The following explanations will suffice:—

(A) From a hayfield by the river Cam near Barnwell, close to Cambridge. These plants were examined weekly, through February and half of March, and afterwards as occasion permitted. They competed with the growing grass; and while this remained short, received sufficient sunlight. The locality is damp.

(B) From a garden almost adjoining the hayfield (A). There was no competition, but the locality is rather shaded. The plants were examined as in the last.

[25] "On the Fertilization of Winter-flowering Plants." Nature, i. p. 11 (1870).

[26] Review of Hoffmann's 'Culturversuche ü. Variation.' Bot. Centralblatt, xx. p. 266, footnote.

[27] "Ueber d. Einfluss d. Lichtes auf d. Gestaltung u. Einlage d. Blüthen." Pringsheim's Jahrbuch, 1893, xxv. p. 149.

[28] "Ueber gelegentliche Kleistogamie." Verhandl. d. Bot. Vereins d. Provinz Brandenburg, 1893, xxxv. p. 148.

[29] "Zur Kleistogamie u. Samenverbreitung d. Collomien." Bot. Zeitung, xxxvi. p. 739 (1878).

Table I.

Number and Percentage of Flowers of Stellaria media *of varying degree of completeness in Andrœcium.*

Number of		A.		B.		C.		D.		E & F.		G.	H.	I.	J & K.	L.	Total.	
Stamens.	Staminodes.	No.	%	No.	%	No.	%	No.	%	No.	%	No.	No.	No.	No.	No.	No.	%
0	......	......	......	......	......	......	......	1	......	2	......	......	......	......	......	......	3	·05
1	......	......	......	1	......	1	......	3	......	......	......	......	......	......	......	1	6	·11
2	......	15	*2·94*	16	*2·86*	27	*1·29*	43	*3·37*	7	......	2	......	1	1	1	113	1·99
3	......	268	*52·55*	334	*59·64*	764	*36·38*	656	*51·49*	94	*26·70*	90	52	23	60	29	2370	41·70
4	......	88	*17·25*	97	*17·32*	532	*25·33*	254	*19·94*	100	*28·41*	63	26	11	106	16	1293	22·75
5	......	87	*17·06*	45	*8·04*	553	*26·33*	114	*8·95*	107	*30·40*	54	18	10	175	4	1167	20·53
6	......	6	......	14	*2·50*	83	*3·95*	......	......	5	......	8	......	1	51	3	171	3·01
7	......	4	......	6	......	28	*1·33*	......	......	1	......	1	......	......	28	1	69	1·21
8	......	1	......	5	......	7	......	1	......	1	......	1	......	......	12	2	30	·53
9	......	1	......	1	......	6	......	......	......	......	......	......	......	......	3	1	12	·21
10	......	1	......	2	......	2	......	......	......	......	......	......	......	......	1	1	7	·12
0	1	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	1	·02
1	1	2	......	1	......	1	......	3	......	......	......	......	......	......	......	......	7	·12
2	1	12	*2·35*	12	*2·14*	9	......	48	*3·77*	4	......	4	1	......	......	1	91	1·60
3	1	9	......	7	......	14	*·67*	21	*1·65*	2	......	2	3	......	3	......	61	1·07
4	1	6	......	5	......	21	*1·00*	5	......	2	......	2	2	2	4	......	49	·86
5	1	1	......	1	......	8	......	1	......	......	......	......	......	1	3	......	15	·26
6	1	1	......	2	......	9	......	1	......	......	......	......	......	......	2	......	15	·26
7	1	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	2	·035
8	1	......	......	......	......	2	......	......	......	......	......	......	......	......	......	......	2	·035
0	2	1	......	......	......	3	......	8	......	3	......	......	......	......	......	......	15	·26

1	2	1	......	4	......	3	......	26	*2·04*	3	......	......	......	......	......	......	37	·65
2	2	1	......	1	......	5	......	4	......	......	......	......	......	......	......	......	11	·19
3	2	......	......	......	......	2	......	......	......	1	......	......	......	......	......	......	3	·05
5	2	1	......	......	......	2	......	......	......	......	......	......	......	......	......	......	3	·05
6	2	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	1	·02
7	2	1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	·02
0	3	1	......	3	......	8	......	65	*5·10*	8	......	......	......	......	......	......	85	1·49
1	3	......	......	......	......	......	......	5	......	4	......	......	......	......	1	......	10	·18
2	3	......	......	1	......	1	......	......	......	......	......	......	......	......	......	......	2	·035
0	4	......	......	......	......	3	......	10	*·78*	2	......	......	......	......	......	......	15	·26
1	4	1	......	......	......	1	......	3	......	......	......	......	......	......	......	......	5	·09
0	5	1	......	......	......	4	......	1	......	5	......	......	......	......	......	......	11	·19
0	6	......	......	......	......	......	......	......	......	1	......	......	......	......	......	......	1	·02
Total No. of flowers		510	......	560	......	2100	......	1274	......	352	......	227	102	49	450	60	5684	
No. of flowers containing staminodes		39	*7·84*	39	*6·96*	97	*4·62*	202	*15·86*	35	*9·94*	8	6	3	13	1	443	*7·79*
No. of stamens		1816	......	1947	......	8358	......	3886	......	1308	......	881	369	184	2169	236	21154	
No. of staminodes.........		53	......	53	......	158	......	423	......	97	......	8	6	3	15	1	817	
% ditto		......	*1·04*	......	*·95*	......	*·75*	......	*3·31*	......	*2·76*	*·35*	*·59*	*·61*	*·33*	*·17*	......	*1·44*
No. of stamens completely aborted ...		3231	......	3600	......	12484	......	8431	......	2115	......	1381	645	303	2316	363	34869	
% ditto		......	*63·35*	......	*64·29*	......	*59·45*	......	*66·18*	......	*60·09*	*60·84*	*63·24*	*61·84*	*51·24*	*60·50*	......	*61·34*

(C) From a warm sunny cinder-bed in the Cambridge Botanic Gardens (shaded after June 20th). The plants were examined almost every week throughout the whole time in which they flowered.

(D) From the Pinetum in the Cambridge Botanic Gardens. The plants grew in the dense shade of trees of *Cedrus*, *Thuja*, and *Taxus*, and received no direct sunlight. They were examined weekly almost to the end of their flowering period.

(E) and (F) From two pots grown from seed in the 'Intermediate (*i. e.* subtropical) pit' in the Cambridge Botanic Gardens. In E the soil was rich; in F it was mixed with an equal quantity of sand. The plants were examined three or four times a week during the time in which they flowered. Being under glass, they obtained slightly less sunlight than those on the cinder-bed, but received more heat. The pit is kept at an average temperature of 60°–65° during the day, and 55° at night.

(G) From gravelly ground, slightly shaded. Only two examinations were made, both in March.

(H) From damp but sunny ground on Coe Fen, Cambridge. One examination only, which was made in March.

(I) From the cinder-bed above mentioned. One examination, made in August, of the first flowers of a young growth.

(J) and (K) From two pots grown in the open. The same soil used as in E and F; K contained 50 per cent. sand, as in F. All the seed sown in these four pots (E, F, J, and K) was gathered at the same time and from the same place. The roots of these plants were able to spread more freely than those of E and F. Unfortunately an accident caused the death of the plants of both J and K, and prevented the examination of the later flowers.

(L) From the highest point of Seamer Moor, Scarborough (600 feet). The locality is sunny. A single examination made in April.

Extent of Variation.—Hermann Müller * has noted the variation in the number of stamens, remarking that the most weakly plants have the fewest stamens: he points out the frequency with which the stamens are reduced to three. A glance at Table I. shows at once the predominance of this number, no less than 41·70 per cent. of the flowers having three stamens; while

* "Weitere Beobachtungen ü. Befruchtung der Blumen durch Insekten." Verhandl. d. naturhist. Vereins d. preuss. Rheinland u. Westfalens, xxxvi. p. 228 (1879).

22·75 have four, and 20·53 per cent. have five stamens. There is no other number which is represented by so high a percentage as five. *Stellaria*, then, has a very strong tendency to be triandrous, and but very rarely (here ·12 per cent.) exhibits the ten stamens characteristic of the Caryophyllaceæ. In Table I., out of the possible total of 56,840 stamens, 21,154 (37·22 per cent.) are present, and 817 (1·44 per cent.) are represented as staminodes; therefore 61·34 per cent. of the possible number of stamens are aborted *.

Effect of Age of the Plant.—The younger the plant is, the more stamens do the flowers carry; thus in experiments E and F, which were not subject to changes of temperature, the following results were obtained :—

TABLE II.

Effect of Age of Plant on Number of Stamens aborted in the Flowers of Stellaria media.

Period.	E.		F.	
	No. of flowers.	Percentage of stamens aborted.	No. of flowers.	Percentage of stamens aborted.
April 13th to May 1st ...	80	54·5	40	51·75
May 2nd to 17th	63	62·22	27	60·0
May 18th to June 1st ...	70	63·43	19	69·47
June 2nd to 23rd	38	64·74	15	67·33

Nor is this result alone; J and K gave similar results; and A, B, C, and D all show a reduction in number of stamens towards the end of the life of the plant, but with certain irregularities.

Table IV., which gives the changes in A, B, C, and D from week to week, shows that towards the end of the life of the plant the average number of stamens draws nearer to three to a

* I cannot agree with Müller when he says that the honey-glands remain, while the stamens to which they belong abort; for from my observations I find the nectaries disappearing with the stamens. *Cf.* 'Fertilization of Flowers (London, 1883), p. 136.

flower, or 30 per cent. On the last occasion of my examining the plants on the cinder-beds (Aug. 7th), when those of C were showing that they certainly could not exist any longer, I took advantage of a young growth (I), 4 inches high, side by side with the old plants, to make a comparison, which gave the following result:—

TABLE III.

Effect of Age on Number of Stamens developed in the Flowers of Stellaria media.

	No. of flowers.	No. of stamens.	No. of staminodes.	Percentage of stamens present.
Very old plants.........	49	159	3	32·45
Very young plants ...	49	184	3	37·55

And so, as the ♀ organs do not change with age, the plant appears to become less ♂ (less ☿ by reduction of ♂) as it grows older.

Effect of Temperature.—Warmth, as Müller* thought possible, appears to have an effect in increasing the number of stamens; this is shown in Table I.: E and F were grown in the warmest place; and in them the flowers with three stamens (26·70 per cent.) were less numerous than those with four or five stamens (28·41 and 30·40 per cent. respectively): of the other columns, C was from a warmer place than the rest; and here the percentage of four- and five-stamened flowers is larger than in any other case, except that of E and F just quoted. In Table IV. the variation from week to week is given. From data kindly supplied to me by Mr. H. F. Newall I have endeavoured to find causes for the marked irregularity seen in it, but with no great success. The one marked Cold period (Feb. 18 to 24) *may* have had some effect, but otherwise, wet or dry, hot or cold weather seems to have passed without any definite influence.

* 'Fertilization of Flowers,' p. 135.

TABLE IV.—*Variation in the Percentage of Stamens and Staminodes developed, as observed from week to week.*

In week from	A.			B.			C.			D.		
	No. of flowers.	% of stamens.	% of staminodes.	No. of flowers.	% of stamens.	% of staminodes.	No. of flowers.	% of stamens.	% of staminodes.	No. of flowers.	% of stamens.	% of staminodes.
Feb. 4–10	44	31·13	·46	......	......	......	106	37·45	1·04			
,, 11–17	16	39·38	0	66	31·67	2·12	121	39·09	1·24			
,, 18–24	46	35·93	1·96	68	34·27	·29	124	42·26	·64	80	29·51	4·62
,, 25–March 3	64	39·06	·94	111	40·0	1·08	120	46·67	·33	100	25·20	7·0
March 4–10	91	35·93	·99	101	32·78	·89	113	40·97	1·68	120	31·59	1·83
,, 11–17	120	37·83	2·0	82	34·27	1·10	79	41·65	1·01	91	30·11	2·64
,, 18–24	......	......	......	......	......	......	137	40·44	·51	83	32·17	1·69
,, 25–31	......	......	......	......	......	......	108	43·24	·46	129	35·97	·23
April 1– 7	......	......	......	......	......	......	109	40·09	·73	114	35·62	·26
,, 8–14	......	......	......	......	......	......	74	41·35	·95	86	33·72	·35
,, 15–21	102	33·14	·20	54	40·37	·93	106	39·81	·57	......	......	......
,, 22–28	......	......	......	......	......	......	......	......	......	......	......	......
,, 29–May 5	......	......	......	......	......	......	60	40·50	·17	67	34·62	·75
May 6–12	......	......	......	......	......	......	......	......	......	......	......	......
,, 13–19	......	......	......	......	......	......	102	39·40	·20	73	32·87	1·92
,, 20–26	27	32·96	·37	78	29·61	·26	115	37·99	·18	63	34·76	·48
,, 27–June 2	......	......	......	......	......	......	100	38·60	·80			
June 3– 9	......	......	......	......	......	......	......	......	......	97	22·78	9·59
,, 10–16	......	......	......	......	......	......	131	37·62	·61	119	20·16	12·02
,, 17–23	......	......	......	......	......	......	114	42·27	·35	52	29·62	·19
,, 24–30	......	......	......	......	......	......	97	36·46	1·03			
July 1– 7.												
,, 8–14.												
,, 15–21	......	......	......	......	......	......	53	31·70	3·21			
,, 22–28	......	......	......	......	......	......	82	40·48	·37			
,, 29–Aug. 4.												
Aug. 5–11	......	......	......	......	......	......	49	32·45	·61			

Richness of the Soil.—We might have almost expected that plants of B growing freely, removed from competition, would have produced more stamens than those of A, where the competition was severe. But such was not the case. E, F, J, and K were, as already stated, grown—E and J in rich soil, F and K in soil one half of which was sand. The seeds were collected in 1892 in the Botanic Garden, and sown in these four sets in February; the pots containing E and F were then placed in a hothouse, while J and K were grown out of doors. The following table gives the results obtained:—

TABLE V.

Percentage of Stamens and Staminodes in Flowers of Stellaria media *grown in Rich and Poor Soil.*

	No. of flowers.	% of staminodes present.	% of perfect stamens present.
E. Rich soil, hothouse, April 13 to June 23...	251	2·19	37·33
F. Poor " " "	101	4·16	36·34
J. Rich soil in open, May 7 to June 30	360	·36	48·94
K. Poor " " "	90	·22	45·22

Note.—J and K were accidentally killed; otherwise the later flowers would have reduced the high percentage of stamens. These plants were slower in growth and more vigorous than those of E and F.

The percentages of stamens in E and F and in J and K in these four experiments lie so very near to one another, that poor nourishment to the extent here produced seems to have had no distinct effect on these organs. The only decided influence which the sand in the soil seems to have had is on the number of flowers borne by the plants themselves.

As soon as E and F had finished flowering, the pots were resown (July 6th), in order to see if the soil would bear freely a second crop. The plants of this second sowing began to flower, those in poor soil on August 2nd, those in rich soil on August 11th; but I was not able to observe them thoroughly. The new plants in both the poor and rich soil were strong; and of the thirteen

flowers first produced, six had 3 stamens, and seven 4 stamens, the majority of the four-stamened flowers being on the plants in poor soil.

Staminodes.—The first question in connexion with these organs which one naturally asks is, Do the same conditions bring about contabescence (reduction of stamens to staminodes) which bring about the complete abortion of the stamens? In Table IV. is given the change from time to time observed in the percentage of stamens developed. Table VI., using the same facts, is an

TABLE VI.

Relation of Percentage of Staminodes developed in Stellaria media *to Percentage of Stamens aborted.*

Percentage of stamens completely aborted.	A.		B.		C.		D.		Total.	
	No. of flowers examined.	Percentage of staminodes.	No. of flowers examined.	Percentage of staminodes.	No. of flowers examined.	Percentage of staminodes.	No. of flowers examined.	Percentage of staminodes.	No. of flowers examined.	Percentage of staminodes.
52·5–55 °/o......	......	......	......	......	120	·33	......	......	120	·33
55·0–57·5	......	......	......	......	538	·81	......	......	538	·81
57·5–60	......	......	165	1·03	798	·69	......	......	963	·75
60·0–62·5	200	1·50	......	......	554	·56	......	......	754	·81
62·5–65	137	1·31	82	1·10	97	1·03	373	·38	689	·74
65·0–67·5 ... }	173	·29	235	1·06	102	1·96	533	2·14	999	1·62
67·5–70 ...... }			......	......	......	......	316	9·30	360	8·22
70·0–72·5	......	......	78	·26	......	......	52	·19	130	·23

attempt to express the relationship of the percentages of staminodes observed with regard to the percentages of completely aborted stamens found at the same times. Certainly, with reservation, we can say that a period of greater abortion of stamens appears to be connected with a greater production of staminodes, suggesting that the same conditions produce both the total and partial abortion of the stamens. But at both extremes the staminodes, as we might expect, regarding them as an intermediate

stage in the disappearance, are fewer in number. However, the facts to hand are insufficient to admit of any certainty.

A reduction in the number of stamens present in any individual flower does not predispose to contabescence in those remaining; for taking the figures in Table I., we find that in the 5243 flowers which contain no staminodes, the percentage of aborted stamens is 61·29 (38·71 per cent. stamens developed), while in the 443 flowers which contain staminodes this same percentage is 61·74 (19·92 stamens and 18·44 staminodes developed), *i. e.* they scarcely differ.

Further, Table I. shows us that just as the 3-stamened flowers are the most numerous, so amongst those with staminodes, flowers, where these and the stamens together make up three, are the most numerous, *i. e.* flowers with two stamens and one staminode, with one stamen and two staminodes, or with no stamens and three staminodes. Next to these in number come those where the stamens and staminodes together number four. This suggests that the staminodes are stamens of which adverse circumstances have caused the abortion (*i. e.* it is a reduction of the andrœcium beyond the average degree), and are not due to favourable circumstances calling forth an imperfect stamen in a place where otherwise nothing would have been developed: in other words, as far as *Stellaria* is concerned, contabescence and complete abortion are only forms of the same reaction differing in degree; the one is not consequential in any way of the other. Only we must remember that the more stamens are aborted, the fewer are present to be contabescent, and therefore the number of aborted and contabescent stamens cannot increase proportionally.

Position of the Stamens which most frequently abort.—In a large number of Chickweed flowers the position of the stamens was noted, and from the results we can trace two degrees in the reduction of the 10-androus flower to its present usual 3-androus condition:—

(i) Abortion of the outer ring of stamens of the obdiplostemonous flowers, *i. e.* those superposed to the petals.

(ii) Abortion of the two stamens of the inner ring which are superposed to the two outermost sepals of the quincuncially arranged calyx.

That these two degrees in the reduction of the stamens are

TABLE VII.—*Distribution in Position of Stamens developed in Flowers of* Stellaria media.

	No. of flowers.	No. of stamens.	Outer whorl.		Inner whorl.				Percentages of stamens deduced theoretically by the rules given.		
			No. of stamens of outer whorl.	X. per cent.	No. of stamens superposed to outer sepals.	Y. per cent.	No. of stamens superposed to inner sepals.	Z. per cent.	*x*.	*y*.	*z*.
1-androus	3	3	......	......	......	......	3	*100·0*	......	......	**100·0**
2 "	53	106	......	......	1	*·94*	105	*99·06*	......	......	**100·0**
3 "	1414	4242	1	*·02*	57	*1·34*	4184	*98·64*	......	......	**100·0**
4 "	688	2752	37	*1·34*	661	*24·02*	2054	*74·64*	......	**25·0**	**75·0**
5 "	592	2960	55	*1·86*	1128	*38·11*	1777 *	*60·03*	......	**40·0**	**60·0**
6 "	97	582	117	*20·10*	173	*29·73*	292 †	*50·17*	**16·67**	**33·33**	**50·0**
7 "	36	252	76 ‡	*31·59*	67	*26·59*	109 †	*41·82*	**28·57**	**28·57**	**42·85**
8 "	17	136	57	*41·91*	28	*20·59*	51	*37·50*	**37·50**	**25·0**	**37·50**
9 "	6	54	26	*48·15*	10	*18·52*	18	*33·33*	**44·44**	**22·22**	**33·33**
10 "	6	60	30	*50·0*	12	*20·0*	18	*30·0*	**50·0**	**20·0**	**30·0**

* Two cases of doubling of one of the stamens (inner whorl).
† One case " " " " "
‡ One " " " " (outer whorl).

correctly stated is proved by Table VII., in which the facts are summed up. In the last three columns, lettered x, y, and z, the percentages of the various stamens which should be present according to these two rules are given; while in the other columns the numbers and percentages actually found are stated. Columns X, Y, and Z correspond with the columns x, y, and z; and it will be noticed that the discrepancy between the real percentages and those found by these two rules is in no case as great as 5 per cent. The constancy of the three stamens of the inner whorl superposed to the inner sepals is most marked, 1·03 being the greatest difference between the figures in columns Z and z. With regard to other stamens, it will be noticed that frequently the percentage of the stamens of the outer whorl is upwards of 5 per cent. greater than the theoretical figure of column x, while that of the stamens superposed to the outer sepals is the same amount too small. Then to this slight extent the stamens of the outer whorl have usurped the place which theoretically should belong to the two outer-sepaline stamens; in other words, the outer whorl does not exhibit so strong a tendency to abortion that it entirely disappears before abortion begins in the inner whorl.

It may be mentioned here that of the five cases in which a doubling of a stamen was observed, in four of these cases it occurred in the inner-sepaline stamens, once in the petaline stamens, and never in the outer-sepaline stamens.

With regard to the petaline stamens, that marked α in the accompanying woodcut is the one most frequently developed. Of the other four (β), none can be said to be much more frequent than the others.

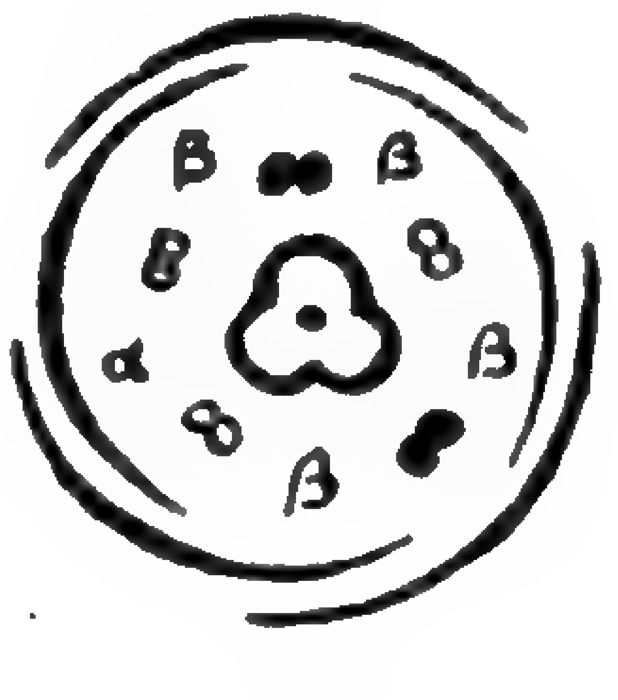


Diagram showing position of stamens with regard to the sepals and ovary. Petals not inserted. The stamens of the petaline whorl are indicated by the letters α and β, those of the sepaline whorl usually absent are shaded.

Changes in the Carpels.—The number of carpels entering into the ovary may be regarded as constant. Out of the 5697 flowers

examined (5684 of Table I. and 13 from second sowing in pots E and F), eight were found with 4 stigmas, and eight with 2. Besides these, two flowers were found with the ovary partly aborted and functionless. Thus we get andromonœcism as well as gynomonœcism; but perhaps we should say only as an abnormality. I have not yet found the gynodiœcism which Warming records *.

Correlations in Number of Parts.—In the eight flowers with only two stigmas, 26 stamens and a staminode were present, while in the eight flowers with four stigmas 35 stamens were present.

Other abnormalities were observed in the petals and sepals as follows †:—

TABLE VIII.

Abnormal Flowers of Stellaria media.

No. of flowers.	No. of sepals.	No. of petals.	No. of stamens.
1	6	6	4
4	6	5	4, 4, 4, and 5
1	4	4	4
2	4	5	3 and 4
1	5	6	5
1	5	2	4

Such numbers are too small to allow us to trace any correlation; but they show that abnormalities in the petals and sepals amount here to but little more than one in a thousand flowers.

It must not be thought that all the flowers, open at one time on a single branch, contain the same number of stamens; this is far from being the case; 3-, 4-, 5-, &c. stamened flowers stand side by side very frequently. The following Table (IX.), in which staminodes are counted in with the stamens, gives the number of cases in which flowers with the same and different numbers of stamens were associated together. No flowers are included which were not of the same age, or were removed from each other by several internodes.

* *Loc. cit.*

† 4-merous flowers (apetalous) are recorded as typical in Alpine Sikkim specimens. Hooker, 'Flora of British India,' i. p. 230 (London, 1875).

TABLE IX.

Number of Stamens in neighbouring Flowers of Stellaria media.

No. of stamens in one flower .... which was associated with :—	1	2	3	4	5	6	7	8	9	10
a 2nd flower containing 1 stamen in	0	cases.								
" " " 2 stamens	0	4								
" " " 3 "	2	20	240							
" " " 4 "	0	4	128	39						
" " " 5 "	0	1	69	81	39					
" " " 6 "	0	0	4	8	10	2				
" " " 7 "	0	0	0	2	4	1	0			
" " " 8 "	0	0	0	0	0	0	3	2		
" " " 9 "	0	0	0	1	1	0	2	1	0	
" " " 10 "	0	0	0	0	0	0	0	1	1	0

But though the Table shows that neighbouring flowers are not uniformly alike, it shows that where there is a difference, this difference is not great. Thus, two flowers with three stamens appeared side by side in 240 cases, but flowers with three and four stamens stood side by side in 128 cases; but in no instance were flowers with three stamens associated with flowers with more than six stamens. The greatest discrepancy observed was that a 4- and a 9-stamened flower in one case stood side by side. Summing up Table IX., we see that in

326 cases the neighbouring flowers were alike.
245 cases there was a difference of 1 stamen.
90 " " " 2 stamens.
7 " " " 3 "
1 case " " 4 ,
1 " " " 5 "

And so, though more often than not the neighbouring flowers were unlike, still there is a considerable tendency towards uniformity.

Caltha palustris, *Linn.*

Hoffmann * has pointed out that with the advancing season the flowers of *Papaver Rhœas*, L., on any given plant become smaller, the latest flowers being the smallest of all. Such is noticeably the case in *Caltha palustris* also: the terminal flower of a branch is always the largest; and, further than this, Table X. (p. 234) shows that it contains more stamens and carpels than the other flowers of the same stem. This Table is derived from the study of 102 flowers from the clay cliffs of Cayton Bay, near Scarborough. In it the first two figures of each line express the sums of the stamens and carpels (or their average) for the whole of the flowers of that rank. The terminal flower of a branch carrying five flowers is richer in stamens and carpels than the terminal flower where fewer flowers are present. And therefore the average obtained for the terminal flowers will depend largely upon how many weak and how many strong branches have been examined. To avoid error from this source, in Table X. the statistics of the total of stamens and carpels for the flowers of any rank are arranged according to the number of flowers borne by the inflorescence. Thus out of the 36 branches examined, three carried only a single terminal flower; and for these three flowers the number of stamens averaged 80·67, or considerably below the average of the terminal flowers where the inflorescence bore four or five flowers. And for this reason Table X. is so arranged that by glancing up the column one can see how the average number of stamens increases in flowers produced earlier on the same stems. It shows, then, that the oldest flowers carry the most stamens and carpels, and that the strongest branches, *i. e.* those which produce most flowers, have in these flowers more stamens and carpels than the flowers in corresponding positions on weaker stems.

Ranunculus arvensis, *Linn.*

A number of plants gathered at Sawbridgeworth (Essex), and examined on May 31st, gave results showing that, as in *Caltha*, the first flower carries more stamens than the later flowers; the number of carpels varied irregularly. Owing to the very

* 'Rückblick auf meine Variations-Versuche,' *loc. cit.* p. 366.

TABLE X.—*Number of Stamens and Carpels in Flowers of* Caltha palustris *according to Strength of Branch.*

Branch	1-flowered.		2-flowered.		3-flowered.		4-flowered.		5-flowered.		7-flowered.		8-flowered.		9-flower ed.		Ratio of stamens to 1 carpel.
	Stamens.	Carpels.	Stamens.	Carpels.	Stamens.	Carpels.	Stamens.	Carpels.	Stamens.	Carpels.	Stamens.	Carpels.	Stamens.	Carpels.	Satmens.	Carpels.	
Terminal flower	242	14	825	76	486	42	1415	122	201	17	98	6	105	8	103	9	12·04
Average	*80·67*	*4·67*	*91·67*	*8·44*	*81·5*	*7·0*	*109·1*	*9·4*	*100·5*	*8·5*	*98·0*	*6·0*	*105·0*	*8·0*	*103·0*	*9·0*	
1st lateral flower	......	......	784	58	541	46	1293	98	169	9	88	6	103	10	95	6	13·78
Average	......	......	*86·0*	*6·44*	*90·17*	*7·69*	*99·46*	*7·54*	*84·5*	*4·5*	*88·0*	*6·0*	*103·0*	*10·0*	*95·0*	*6·0*	
2nd lateral flower...........	......	......	......	......	425	32	1123	94	167	14	85	7	108	9	100	10	12·10
Average	......	......	......	......	*85·0*	*6·4*	*93·6*	*7·53*	*83·5*	*7·0*	*85·0*	*7·0*	*108·0*	*9·0*	*100·0*	*10·0*	
3rd lateral flower	......	......	......	......	......	......	129	6	155	11	85	6	111	8	93	8	14·77
Average	......	......	......	......	......	......	*64·5*	*3·0*	*77·5*	*5·5*	*85·0*	*6·0*	*111·0*	*8·0*	*93·0*	*8·0*	
4th lateral flower	......	......	......	......	......	......	......	......	76	3	......	......	......	......	76	5	19·0
Average	......	......	......	......	......	......	......	......	*76·0*	*3·0*	......	......	......	......	*76·0*	*5·0*	
1st branch of 1st lateral ...	......	......	......	......	68	6	980	77	64	4	85	4	106	8	86	7	13·10
Average	......	......	......	......	*68·0*	*6·0*	*81·67*	*6·42*	*64·0*	*4·0*	*85·0*	*4·0*	*106·0*	*8·0*	*86·0*	*7·0*	
2nd branch of 1st lateral...	......	......	......	......	......	......	......	......	......	......	74	4	106	7	84	7	14·67
Average	......	......	......	......	......	......	......	......	......	......	*74·0*	*4·0*	*106·0*	*7·0*	*84·0*	*7·0*	
1st branch of 2nd lateral...	......	......	......	......	......	......	......	......	......	......	69	4	96	7	80	8	12·89
Average	......	......	......	......	......	......	......	......	......	......	*69·0*	*4·0*	*96·0*	*7·0*	*80·0*	*8·0*	
1st branch of 4th rank......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	71	6	11·82
1 extra 1st lateral bud......	......	......	......	......	......	......	......	......	......	......	......	......	112	10	......	......	11·20
												Total......	11,453 stamens...... 891 carpels.				12·85

fugaceous nature of the stamens, these were not counted in thirteen flowers in which the carpels were examined.

TABLE XI.

Number of Stamens and Carpels in Flowers of Ranunculus arvensis *according to Position on Branch.*

	No. of flowers.	Average no. of stamens.	No. of flowers.	Average no. of carpels.
Terminal flowers	12	15·6	23	6·04
1st lateral flowers............	22	13·18	23	6·04
2nd ,, ,, ...	20	14·0	21	6·29
3rd ,, ,, ...	5	12·2	5	5·6
1st branch of 1st lateral ...	14	12·93	14	6·21
2nd ,, ,, ,, ...	7	13·14	7	7·0
1st ,, 2nd ,, ...	9	13·33	9	6·44
2nd ,, ,, ,, ...	2	12·5	2	6·0
Total	91	......	104	
Average	......	13·78	......	6·19

RANUNCULUS BULBOSUS, *L.*

Here, as in the last, the terminal flowers have more stamens than the lateral ones: Table XII. shows this. The plants examined were obtained from Chesterton, near Cambridge, on April 13th.

The long summer of 1893 caused this plant to begin a second flowering late in October of that year; and, as a consequence of this, I obtained from the locality above mentioned, between January 29th and February 26th, 1894, twenty-four flowers. These flowers, developed in a very much colder period than the spring flowers, had much fewer stamens and carpels.

TABLE XII.

Number of Stamens and Carpels in Flowers of Ranunculus bulbosus.

	Average number		Ratio of stamens to 1 carpel.
	of stamens.	of carpels.	
Spring flowers. Terminal	64·0	35·89	1·78
,, ,, Lateral	54·9	32·0	1·72
Winter flowers	42·17	21·08	2·0

From very poor soil at Watton, in Norfolk, I gathered in May a number of terminal flowers to see if the smallest flowers borne by dwarf plants had fewest stamens and carpels. Such in part seemed to be the case. Amongst the smallest flowers I obtained one in which all the stamens, fifty-two in number, were reduced to staminodes *.

RANUNCULUS FICARIA, *Linn.*

Effect of Time of Flowering on the Number of Stamens and Carpels.—As in the former case of *Stellaria media*, so here the later flowers borne by the plant have fewer stamens and carpels than the earlier flowers.

TABLE XIII.

Reduction in Number of Stamens and Carpels in later Flowers of Ranunculus Ficaria.

Locality.	Date.	No. of flowers.	Average				Ratio of stamens to 1 carpel.
			No. of sepals.	No. of petals.	No. of stamens.	No. of carpels.	
Cambridge, under trees................	March 3rd	32	3·08	7·56	22·87	13·41	1·70
	April 16th	75	3·25	8·0	19·49	11·95	1·63
Cayton Bay, top of cliffs, open field.	March 31st	100	3·03	8·52	38·24	32·32	1·18
	May 4th	43	3·05	8·35	30·67	25·72	1·19
Cayton Bay, thin wood on cliffs ...	March 31st	56	3·05	8·68	37·96	35·41	1·07
	May 4th	12	3·0	8·42	30·0	25·92	1·16

Müller † states that in this plant and *Ranunculus Auricomus* the number of petals increases with the season.

Effect of Conditions.—A large number of flowers were examined besides those given in Table XIII., in order to see if different conditions affected the number of parts in the flowers. The results are contained in Table XIV.

* Whitelegge, "Gynodiœcious Plants," Nature, xviii. p. 588 (1878), records female flowers of *Ranunculus bulbosus* as having the petals reduced in size.

† 'Fertilization of Flowers,' p. 78.

TABLE XIV.

Number of Stamens and Carpels in Flowers of Ranunculus Ficaria.

Locality.	Date.	No. of flowers.	Average				Ratio of stamens to 1 carpel.
			No. of sepals.	No. of petals.	No. of stamens.	No. of carpels.	
Under trees, poor soil.							
Beresford Dale, Staffordshire.	March 26th	75	3·75	7·36	22·52	19·14	1·18
Forge Valley, Scarborough.	April 9th	67	3·01	8·45	27·24	18·15	1·50
Sunny banks facing south.							
Ashbourne	Mar. 21 & 22	84	3·13	8·42	30·42	17·59	1·73
Ravine, Filey ...	April 5th	28	3·03	8·25	34·36	20·25	1·69
Slopes facing east.							
Cliffs, Scarborough.	Mar. 29 & 30	64	3·13	8·52	38·03	32·89	1·16
Cliffs, Cayton Bay (base)	March 31st	45	3·07	8·82	41·44	34·20	1·21
Open field.							
Top of CastleHill, Scarborough.	April 4th	20	3·0	8·70	34·30	28·65	1·19
Coe Fen, Cambridge.	April 16th	86	3·02	8·07	30·67	20·55	1·49

That conditions do affect the number of parts seems certain; but it is difficult to say what the conditions are. The flowers gathered from the somewhat inhospitable mountain limestone of Beresford Dale, near Hartington, are those in which the number of stamens is lowest. The flowers gathered in various spots from the boulder-clay near Scarborough, *i. e.* Cayton Bay (3), Castle Hill and cliffs, all show a large number both of stamens and carpels, and the ratio of stamens to carpels varies but little. On the contrary, the proportion of stamens to carpels is much higher in plants from Forge Valley, Ashbourne, and Cambridge. The Filey plants were from boulder-clay, but do not agree with the other boulder-clay plants,—perhaps because of the steepness of the bank on which they grew. The plants from Coe Fen, grown under similar conditions to those from the top of the cliffs at Cayton and on the Castle Hill at Scarborough, *i. e.* amongst grass, instead of resembling these, resemble those

from under trees in Cambridge. Such being the case, it appears as if the soil might influence the proportion of stamens to carpels, if not also the number of these.

Correlations.—The foregoing Tables show that there is a proportion between stamens and carpels, probably constant under the same conditions, and at any rate unaffected by the decrease in number of parts which occurs as the flowering period passes over (*cf.* Table XIII.). But beyond this the number of stamens and carpels possesses a definite relation to the number of petals, most decidedly shown throughout the flowers which I examined *. The following will serve as instances :—

TABLE XV.

Correlation in increase in number of Petals, Stamens, and Carpels in Flowers of Ranunculus Ficaria.

Flowers with 3 sepals.	Cambridge No. 1.			Ashbourne.			Cayton Cliffs, Top, No.1.		
	No. of flowers.	Average of stamens.	Average of carpels.	No. of flowers.	Average of stamens.	Average of carpels.	No. of flowers.	Average of stamens.	Average of carpels.
7 petals...	11	22·54	12·91	1	23·0	16·0	4	37·0	39·0
8 „ ...	18	23·55	13·88	53	30·45	16·77	60	36·73	31·33
9 „ ...	0	......	......	19	31·05	18·21	19	40·26	36·68
10 „ ...	0	......	......	4	34·0	22·0	13	42·54	42·23

But with regard to the sepals there is no such correlation. In the flowers obtained from Beresford Dale there was a considerable number with more sepals than three, the petals usually being reduced in number corresponding with the increase in number of the sepals. Table XVI. shows this.

* H. Müller has given for *Myosurus minimus*, 'Nature,' xxvi. p. 81, 1882 (and x. p. 129, 1874), the results of the examination of approximately 400 flowers. His figures show, but not very distinctly, some correlation between the numbers of petals and stamens; and he remarks that the greater number of organs was accompanied by greater size of the flower.

TABLE XVI.

Want of Correlation in increase between Sepals and Stamens and Petals and Carpels in Ranunculus Ficaria.

No. of flowers.	No. of sepals.	No. of petals.	Average no. of stamens.	Average no. of carpels.
20	3	8	22·75	17·6
14	4	7	20·36	18·43
8	5	6	17·0	19·12

Then while the number of stamens proved to decrease with the number of petals, the number of carpels increased. Such a result is curious, and a natural supposition would be that some very abnormal flowers had interfered with the correct results. But this is not the case; and, further, the results of the examination of flowers from other places all show that the more sepals are present, the more nearly equal are the numbers of the stamens and carpels.

THALICTRUM FLAVUM, *Linn.*

Effect of Position of Flower on Number of Carpels.—In this plant the stamens are too fugaceous to yield reliable results. Nearly all the flowers of the inflorescence mature at the same time; but their position determines, to a great extent, the number of carpels. In the axil of each bract usually arise two branches, the lower of which generally bears a single flower, while the upper may branch and carry three or more flowers (as at

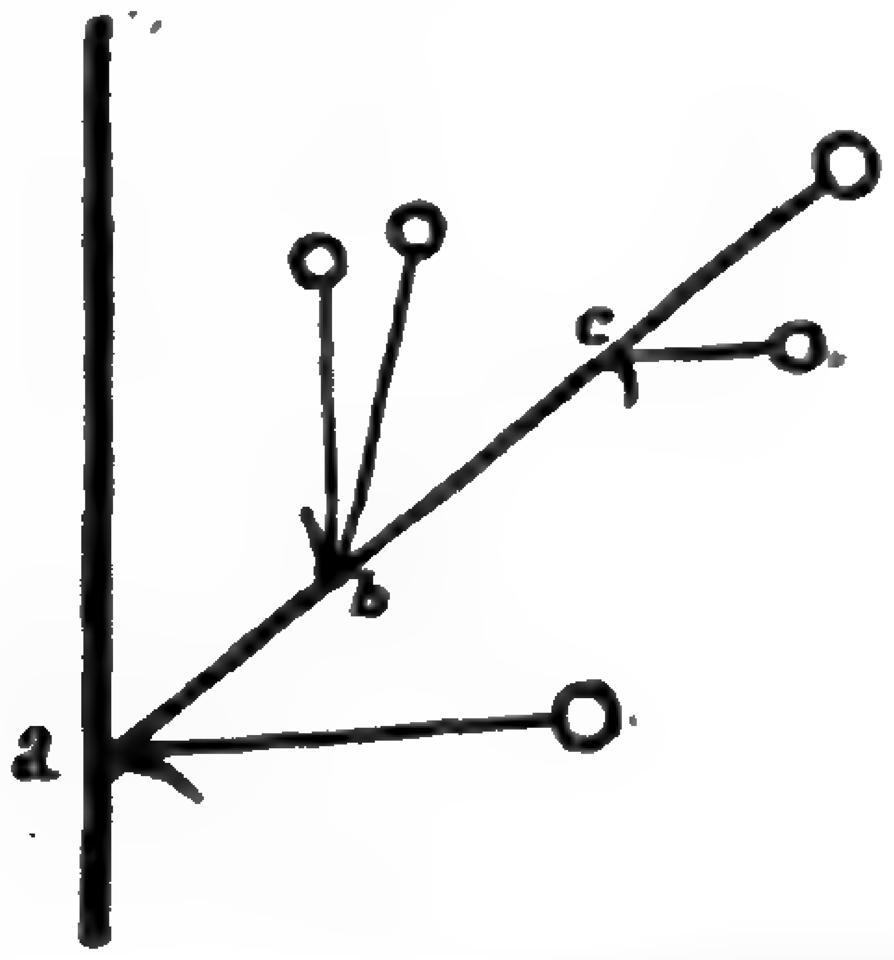


Diagram showing common arrangement of flowers in *Thalictrum.*

a in the diagram). This upper branch is usually the strongest. Often only one branch is present (as at *c* in the diagram). When

two branches are present each with only one flower (*b* in the diagram), the lower shows itself stronger in producing more carpels: when the inflorescence is more vigorous, the upper branch and not the lower takes the lead, producing 2 to many flowers; but these, as a rule, carry fewer carpels than the terminal flower of the lower branch.

TABLE XVII.

Number of Carpels in Flowers of Thalictrum flavum *according to Position on Branch.*

	No. of cases.	Average no. of carpels in terminal flower of lower branch.	Average no. of carpels in terminal flower of upper branch.	Average no. of carpels in lateral flowers of upper branch.
One branch only developed (*c*)	30	8·8		
Upper branch unbranched (*b*).........	44	9·86	8·02	
" " 2-flowered	4	10·75	9·0	8·25
" " 3 "	6	10·33	6·5	8·67
" " 4 " (*a*)	1	11·0	8·0	7·67
" " 5 "	4	10·0	8·0	9·75
" " 6 "	1	9·0	Aborted.	8·0
" " 9 "	2	11·5	7·5	10·0

This Table shows that the more vigorous (in number of flowers) the upper branch, the more carpels does the lower branch bear; and so the number of carpels is affected by the strength of the axil from which arise the flowers containing them. The lower branch does not itself branch so readily as the upper. When this upper branch carries many flowers, the terminal flower carries fewer carpels than the lateral flowers.

In plants which have usually three branches in the axil instead of two, as is sometimes the case, the results are similar. The plants examined were gathered in Waterbeach Fen, near Cambridge, in July.

Bocconia cordata, *Willd.*

The number of stamens in a flower depends on the strength of the branch which bears it; and consequently there is a definite relation between the number of flowers and the number of stamens; thus the flowers of branches of secondary rank, bearing five flowers, carry more stamens than those on branches bearing three.

Table XVIII.

Number of Stamens in Flowers of Bocconia cordata *according to Vigour of Branch.*

	Average number of stamens in flowers of	
	Branches bearing 5 flowers.	Branches bearing 3 flowers.
Terminal	33	30
Lowest lateral	26·2	26·83
2nd „	27·4	24·29
3rd „	25·4	
4th „	25·2	

If we arrange the flowers according to rank, we see that the branches of higher order carry fewer stamens, thus:—

Table XIX.

Number of Stamens in Flowers of Bocconia cordata *according to Position on Branch.*

	Average no. of stamens.
2 flowers terminating branches of primary rank	33·0
20 „ „ „ secondary „	30·1
35 „ „ „ tertiary „	26·0

In order to avoid error by stamens falling off, the flowers were examined when the buds had not yet opened.

Prunus Padus, *Linn.*

In this plant the number of stamens varied from 26 to 34. The lower flowers of the inflorescence are the first to mature, and usually carry the supernumerary stamens. Thus in 199 flowers on eight inflorescences, the lowermost 103 flowers had the average of 30·62 stamens to a flower, while the upper 96 flowers had the average of 30·46—*i. e.* 16 more stamens per 100 flowers in the lower than in the upper part of the inflorescence.

Prunus Lauro-Cerasus, *Linn.*

In this case the flowers of the inflorescence mature from above downwards, being just the reverse of *Prunus Padus*; and so the upper, older flowers possess the most stamens.

54 lower flowers carried 991 stamens—average 18·35.
54 upper „ „ 1064 „ „ 19·70.

Cratægus Oxyacantha, *Linn.*

In this plant we have a cyme, and here the terminal flower usually carried the most stamens, the others following in ascending order. Two examinations of Hawthorn-flowers were made, one having large (A), the other small flowers (B); both were from the neighbourhood of Cambridge.

Table XX.

Number of Stamens in the Flower of Cratægus Oxyacantha *according to Position on Axis.*

	A. No. of stamens.	Average.	B. No. of stamens.	Average.
Terminal flowers	336	18·5	208	14·9
1st lateral „	239	18·4	111	13·9
2nd „ „	334	18·4	111	13·9
3rd „ „	365	18·2	185	14·3
4th „ „	270	18·0	166	13·8
5th „ „	124	17·7	95	13·6
Branches of higher order...	92	18·5	70	17·5

Rosa canina, *Linn.*

This follows the rule that the terminal flowers carry more stamens and carpels than the lateral flowers.

Table XXI.

Number of Stamens and Carpels in Flowers of Rosa canina *according to Position on Axis.*

8 inflorescences.	Average no. of stamens.	Average no. of carpels.	Ratio of stamens to 1 carpel.
Terminal	82·0	26·87	3·05
1st lateral	69·62	20·25	3·44
2nd „	67·86	20·0	3·39

The terminal flowers *uniformly* carried more stamens and carpels than the lateral flowers.

Quercus Ilex, *Linn.*

In the male catkins the basal flowers carry more stamens than the upper flowers: thus, in eight catkins—

141 basal flowers carried 849 stamens—average 6·02.
141 apical „ „ 682 „ „ 4·84.

By basal flowers those uppermost in the pendulous catkins are implied.

Sagittaria montevidensis, *Cham.*

In the male flowers the lowest carry more stamens than the uppermost, as shown in Table XXII. (p. 244).

Alisma ranunculoides, *Linn.*

In plants from Dernford Fen, near Cambridge, in all the inflorescences examined, the oldest carried more carpels than the youngest.

Table XXII.

Number of Stamens in Flowers of Sagittaria montevidensis *according to Position on Axis.*

	No. of flowers.	No. of stamens.	Average no. of stamens in a flower.
Lowest whorl	5	192	38·4
2nd „	6	193	32·17
3rd „	7	209	29·86
4th „	9	277	30·78
5th „	6	186	31·0
6th „	5	151	30·17
7th „	5	143	28·6
8th „	5	137	27·4
9th „	5	135	27·0
10th „	4	114	28·5
11th „	4	108	27·0

Summary.

In this paper are given the results of the examination of nearly 5700 flowers of *Stellaria media*, Cyr., of upwards of 800 flowers of *Ranunculus Ficaria*, Linn., and of smaller numbers of several other plants, i. e. :—*Caltha palustris*, Linn. (102), *Ranunculus arvensis*, Linn. (104), *R. bulbosus*, Linn. (66), *Thalictrum flavum*, Linn. (242), *Bocconia cordata*, Willd. (57), *Prunus Padus*, Linn. (199), *P. Lauro-Cerasus*, Linn. (108), *Cratægus Oxyacantha*, Linn. (227), *Rosa canina*, Linn. (24), *Quercus Ilex*, Linn. (282), and *Sagittaria montevidensis*, Cham. (60)—numbers in themselves absolutely insufficient to establish any fact other than that the plants do vary; but yet worthy of consideration, inasmuch as they support the main contention of this paper, that *the position of the flower on the axis affects the sexual organs, if they vary.* We have seen how the earlier-formed flowers on the plant carry more stamens or more carpels, or perhaps more

of both organs, than those formed later in the season; and, again, we see that the flowers formed earliest, or holding any position of advantage on an inflorescence, *i. e.* terminal on a cyme or at the base of a raceme, even if not maturing earliest, e. g. *Thalictrum*, carry more stamens or carpels, or more of both, than the other flowers of the same inflorescence. *Stellaria media* and *Ranunculus Ficaria*, where the early and late flowers are separated from each other by a considerable interval of time, show the reduction in later flowers, not necessarily on the same axes as the earlier ones.

The other plants examined show how in the same inflorescence we can appreciate a reduction—now in the stamens, now in the carpels—in the later-formed flowers. What other influences act is a question too involved to answer other than conjecturally. I have suggested temperature in the case of *Stellaria* and *Ranunculus bulbosus*, but am not able to hazard any other cause with any degree of safety. What experiments follow will, I hope, throw further light upon this tangled question.

Apart from these considerations, I have been able to show that the order of abortion in the stamens of *Stellaria media* is fixed and definite; and that in several plants there exists a correlation between the numbers of petals and stamens and of stamens and carpels—a higher average number of one organ being present, there will be a corresponding increase in the other organs.

In conclusion, I desire to express my thanks to Mr. Francis Darwin for much kindly advice, and to Mr. H. F. Newall for the data of temperature and rainfall with which he supplied me. To Mr. R. I. Lynch I am indebted for many services; and, above all, my thanks are due to Mr. J. C. Willis, to whom I owe the original suggestion in regard to these investigations, and who has moreover, rendered me considerable assistance.

On *Chionanthus Ghaeri*, Gaertn. By J. G. Boerlage. (Communicated by the President.)

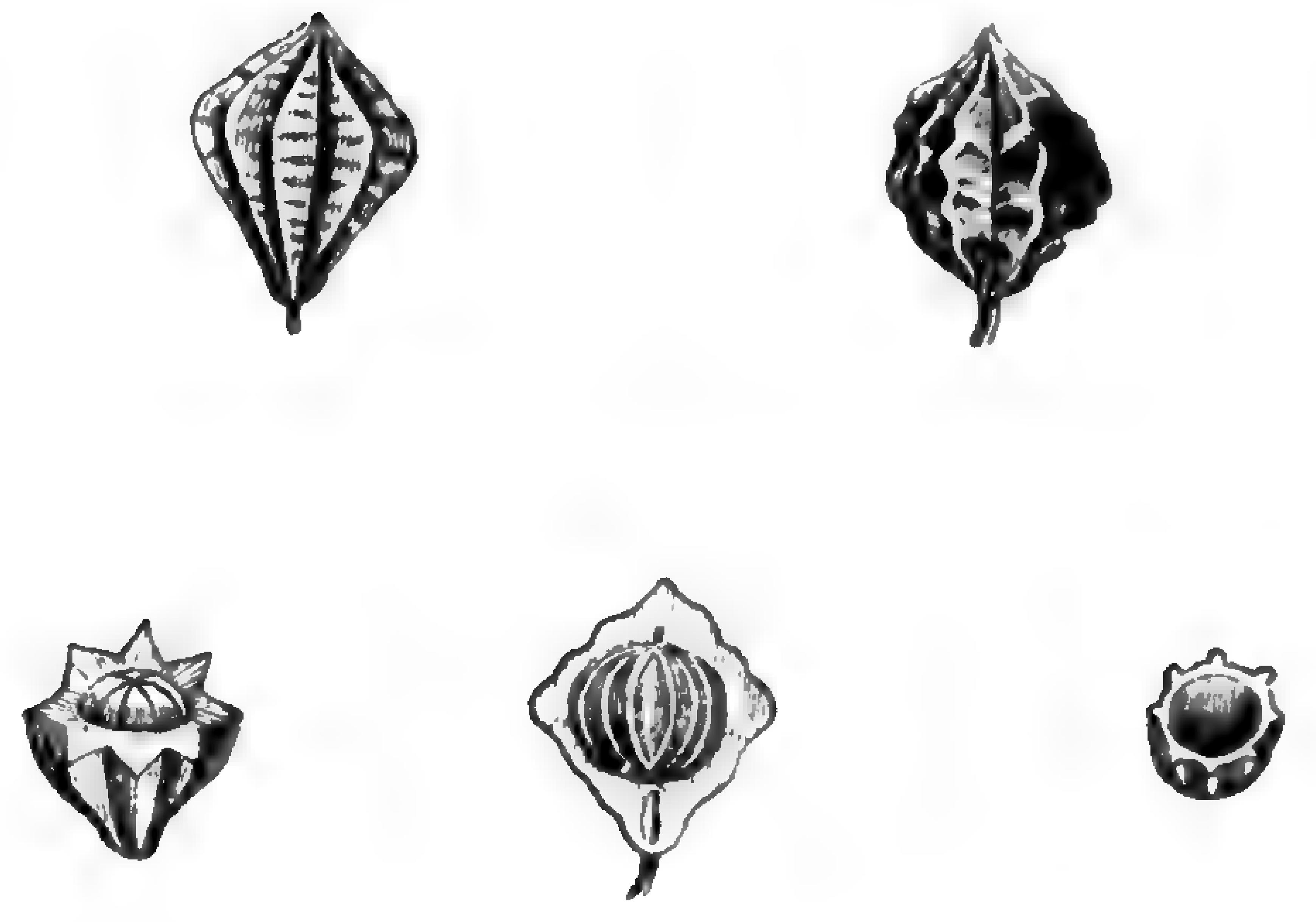
[Read 7th February, 1895.]

The figures in Joseph Gaertner's famous work 'De Fructibus et Seminibus Plantarum,' published at the end of the last century, have not all been recognized. Several of them, especially those which were drawn from incomplete materials, have remained more or less dubious. Such is the case with *Chionantaus Ghaeri*, Gaertn. Nobody considers it to be a *Chionanthus*. In DeCandolle's 'Prodromus,' viii. p. 295, and also in Hooker's 'Flora of British India,' iii. p. 611, it is mentioned as an obscure species. Gaertner relates (i. p. 189) that the fruit figured by him at t. xxxix. fig. 6*, had been received from the collection of seeds in the Leyden Museum. This collection was placed afterwards in 's Ryck's [State] Herbarium, where I found the original materials of the *Chionanthus Ghaeri*; so that I am now able to lift the veil which has hitherto enveloped it. The fruits are accompanied by a ticket on which is written at one side No. 99, Gierietette, at the other side $\frac{99}{1758}$. I suppose that the fruits belonged to a collection brought together in Ceylon in the year 1758. A part of that collection had been sent to Gaertner, containing other species mentioned by him as *Syzygium Idrakul*, *Idrorinda umbellata*, &c. I have some doubt whether the ticket originally belonged to the fruits; some confusion of tickets may have happened, for I find in Hermann's Herbarium a real *Chionanthus*, *C. zeylanicus*, Linn., with the name "Ghaeriatta ghas." Now *ghas* being a common native name for several plants and *ette* for fruits or seeds, it may be that Ghaeriatta and Gieriet are only different spellings of the same name. But it is certain that ticket and fruits have been together for a long time, and that Gaertner had received his specimen with the name. The close agreement of the figure with the fruits leaves no doubt regarding their mutual identity. I am thus enabled to state that *Chionanthus Ghaeri*, Gaertn., not only has to be excluded

* This figure is reproduced in Lamarck, 'Dictionnaire de Botanique,' tab. 9 (*Chionanthus*, fig. 3).

from the genus and also from the family, but even from the Dicotyledonous plants, being a Cyperacea, viz. *Scirpodendron costatum*, Kurz.

Scirpodendron costatum, Kurz.
Specimen authenticum, ad nat.



Chionanthus Ghaeri.
From J. Gaertner, 'De Fructibus et Seminibus Plantarum,' tab. xxxix.

It is very remarkable that this plant, discovered for the first time in Ceylon in the year 1758, was not mentioned as an

indigenous species of that island until a century afterwards, in 1864, by Thwaites in his 'Enumeration of Ceylon Plants,' where it is called *Hypolythrum costatum*, Thw. Probably it is a somewhat rare plant, though its area of dispersion is very large, the species extending to Singapore, Penang, Java, Australia, and Samoa. On the last-named island the fruits are eaten by the natives.

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A GENERAL INDEX to the first twenty volumes of the Journal (BOTANY) and the Botanical portions of the Proceedings from November 1838 to June 1886 may be had on application, in cloth, or in sheets for binding. To those who have been elected Fellows of the Society subsequent to its publication in 1888, the price is 15*s.*

NOTICE.

VOLS. XXVI. & XXXI. are in course of simultaneous issue to expedite the publication of papers, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–213 and 214 (the present Part).

Attention to this announcement is specially requested, to prevent application to the Librarian for unpublished Parts.

The last Meeting of the Society during the present year will be held on December 19th, when the Chair will be taken at 8 P.M. as usual.

May 23. Price 6s.

THE JOURNAL

OF

THE LINNEAN SOCIETY.

Vol. XXXI. BOTANY. No. 215.

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This consists of nine Fellows (three of whom retire annually) and of the four officers *ex officio*, in all thirteen members. The former are elected annually by the Council in June, and serve till the succeeding Anniversary. The Committee meet at 4 P.M., at intervals during the Session. The Members for 1895-96, in addition to the officers, are:—

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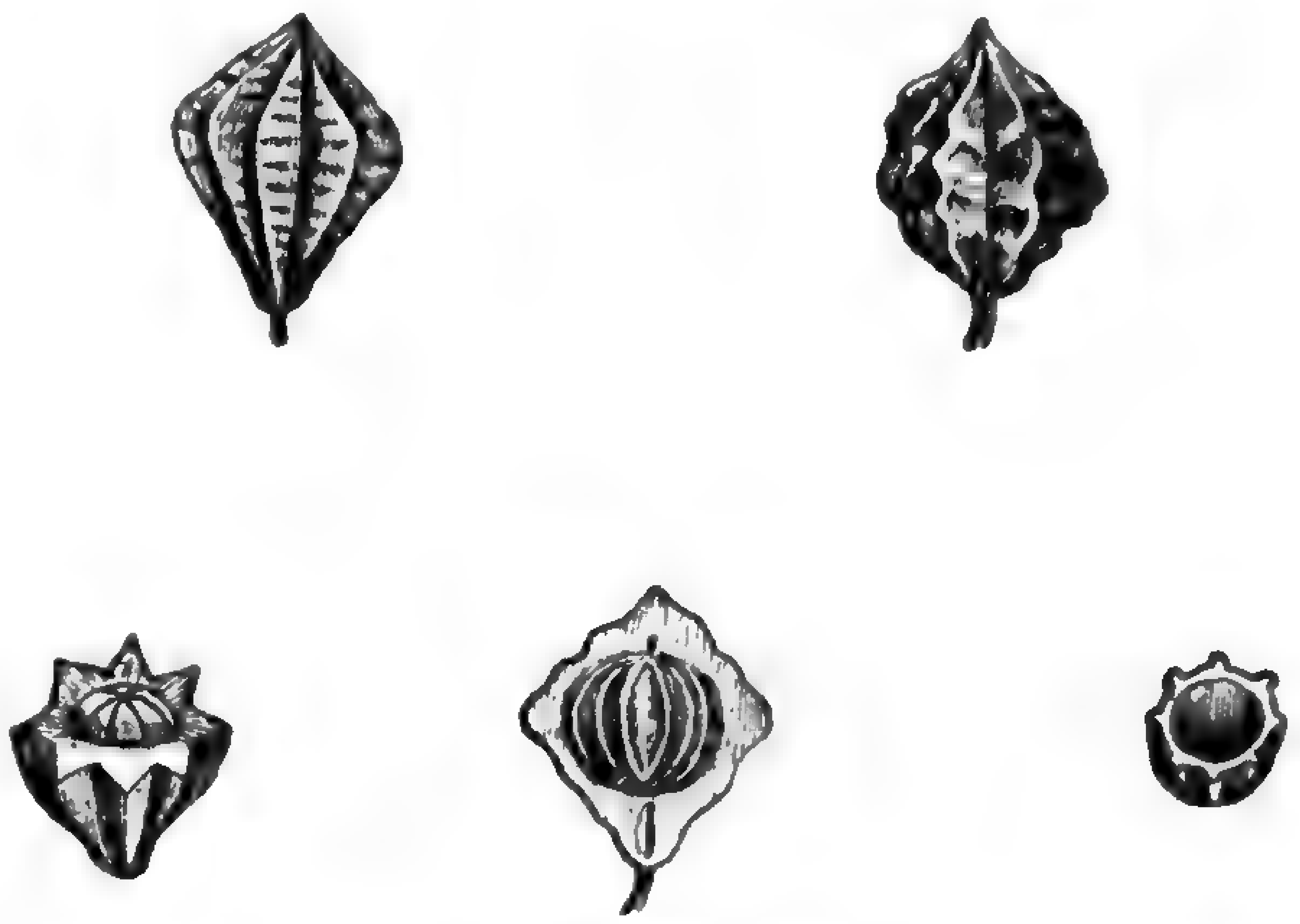
NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

from the genus and also from the family, but even from the Dicotyledonous plants, being a Cyperacea, viz. *Scirpodendron costatum*, Kurz.

Scirpodendron costatum, Kurz.
Specimen authenticum, ad nat.



Chionanthus Ghaeri.
J. Gaertner, 'De Fructibus et Seminibus Plantarum,' tab. xxxix.

It is very remarkable that this plant, discovered for the first time in Ceylon in the year 1758, was not mentioned as an

indigenous species of that island until a century afterwards, in 1864, by Thwaites in his 'Enumeration of Ceylon Plants,' where it is called *Hypolythrum costatum*, Thw. Probably it is a somewhat rare plant, though its area of dispersion is very large, the species extending to Singapore, Penang, Java, Australia, and Samoa. On the last-named island the fruits are eaten by the natives.

New Marine Algæ from Japan. By E. M. Holmes, F.L.S., Curator of the Museum of the Pharmaceutical Society of Great Britain.

[Read 21st February, 1895.]

(Plates VII.-XII.)

Until early in the present century nothing was known of the marine Algæ of Japan; and comparatively little progress has since been made in the study of the Japanese Marine Flora.

Our own countryman, Dawson Turner *, was one of the first to describe the Japanese Algæ brought home by the Russian expedition of Krusenstern, consisting chiefly of species of *Sargassum*. In 1843 † Kützing described others from the same source. In 1856–59 ‡ Harvey published descriptions of some Japanese Algæ collected in two American Expeditions to China and Japan. In 1866 Martens § published an enumeration of all the marine Algæ of Japan already known, adding a few species collected during the Prussian Expedition to East Asia. Elaborate memoirs were published by Suringar ‖ from 1868 to 1874,

* Turner, 'Fuci sive Plantarum Fucorum Generi . . . historia,' 1808–1819.

† Botanische Zeitung, i. p. 53.

‡ Perry, 'Narrative of the Expedition of an American Squadron to China and Japan,' 1856; Harvey, "Characters of New Algæ collected by C. Wright in the North Pacific Exploring Expedition under Capt. J. Rodgers," in Proc. Amer. Acad. vol. iv. 1859.

§ 'Die Preussische Expedition nach Ost-Asien: Tange,' 1866. This enumeration omits, by some oversight, the 54 Algæ collected by C. Wright and published by Harvey.

‖ "Algarum japonicarum Index," Ann. Mus. Bot. L.-B. iii. p. 256. 'Note sur l'hist. des faisceaux chlorophylliens de la *Spirogyra lineata*,' 1868. Algæ Japonicæ, Mus. Bot. Lugd.-Batav., 1870. Musée botanique de Leyde: 'Illustrations des espèces et formes du Genre *Gloiopeltis*,' 1871–72. 'Illustrations des Algues du Japon,' 1874.

describing in detail edible and other Japanese Algæ; and a few Laminariæ were added by Kjellman and Petersen * in 1885, obtained during the expedition of the 'Vega.'

Nevertheless the whole number of the known species was estimated by Hariot † in 1891 at only 233 species. Since that date a few species have been added by F. Schmitz and Reinbold in Germany, and Okamura and Yatabe in Japan, and De Toni in Italy.

The parts of the Japanese coasts that have been hitherto explored are chiefly in the neighbourhood of Hakodadi in the northern island of Yesso, Tokio in the middle island of Nippon, and Nagasaki in the southern island of Liu-kiu, the northern coast not having been worked at all. As out of 150 species sent to me from the neighbourhood of Tokio last year, about 30 have proved to be new, it may be inferred that the coasts of Japan, if thoroughly explored, would yield a rich harvest to algologists. Although the latitude in which North Japan lies is nearly parallel with that of Great Britain, a considerable portion extends much farther south; and it is interesting to find that about one twelfth of the known British species occur in that country, including 2 *Cyanophyceæ*, 9 *Chlorophyceæ*, 13 *Phæophyceæ*, and 25 *Rhodophyceæ*; a list of which is given in the form of an Appendix at the end of this paper.

During the last few years Japanese seaweeds have been forwarded to several European algologists, including Kjellman in Sweden, Hariot in France, De Toni in Italy, and Schmitz and Reinbold in Germany; so that a large accession to the number of known Japanese Algæ may shortly be expected.

The present list of new Japanese Algæ includes only those which I have been able to refer to their genera, since a number of others cannot be determined in the absence of fructification, even the genera to which they belong being uncertain. Of the 23 new species herein described, 4 belong to the *Chlorophyceæ*, 3 to the *Phæophyceæ*, and 16 to the *Rhodophyceæ*.

CHLOROPHYCEÆ.

CLADOPHORA OHKUBOANA, n. sp. (Pl. X. fig. 1); fronde corneo-cartilagineâ, saturate viridi, ad 3–4 pollices longâ, crebre ramosâ, ramis erectis acutis di-trichotomis, ramulorum cellulis

* Kjellman och Petersen, 'Om Japans Laminariaceen,' 1885.

† Hariot in Mém. des Sc. nat. et math. de Cherbourg, 1891, pp. 211–230.

paucis (3–7), articulis primariis 6–8plo, ramulorum 4–6plo diametro longioribus.

Hab. Enoshima, *Ohkubo*, no. 31.

This fine species receives its name from its discoverer, who has added several other interesting species to the Japanese flora, although this is, I believe, his first attempt to investigate the marine Algæ of his neighbourhood. The plant is of a deep, but not dark green colour, resembling that of *C. diffusa*; but the branches are very erect, alternately dichotomous, or occasionally trichotomous, but not fastigiate nor even corymbose, the ramuli being of unequal length. It is about 3–4 inches high. It is nearly allied to *C. rugulosa* and *C. hospita*, but differs from the former in having no annular development at the base of the branches, and from the latter in its smaller stature and in the greater diameter of the cells and their more uniform length, even the basal cell not exceeding in length the diameter by more than 10 times.

Codium cylindricum, n. sp. (Pl. VII. figs. 1 *a*, 1 *b*.); fronde cylindraceâ, simplici, ad 8 pollices longâ, et semiunciam latâ, granulosâ; utriculis clavatis apice rotundatis, diametro quadruplo sextuplove longioribus; colore pallido-viridi.

Hab. Misaki, *Saida*, no. 86.

This remarkable plant belongs to the same section as *C. galeatum* and *C. mammillosum*, in which the utricles are sufficiently large to give a granular appearance to the frond, each being perceptible under a good lens. It is presumed to have a cylindrical form when growing, from the depressed centre of the frond when dried.

Codium divaricatum, n. sp. (Pl. VII. figs. 2 *a*, 2 *b*); fronde repetiter dichotomâ, axillis rotundatis, sub axillis cuneato-dilatatâ, apicibus divaricatis, ad pollices quatuor longâ, 1–2 lineas latâ; utriculis cylindraceis apice dilatatis rotundatis, diametro bis terve longioribus; colore saturate viridi.

Hab. Shimoda, *Saida*, no. 39.

This species bears an external resemblance to small forms of *C. elongatum*, C. Ag.; but in that species the utricles are 5–6 times longer than broad, and the apices are rarely, if ever, divaricate.

Letterstedtia japonica, n. sp. (Pl. VII. figs 3 *a*, 3 *b*, 3 *c*); fronde flabellato-expansâ, ad 2 pollices longâ, profunde laciniatâ,

segmentis cuneatis pinnatim fissis, demum caulescentibus; colore olivaceo-viridi.

Hab. Enoshima, *Ohkubo*, no. 40.

The specimens received are about 2 inches in height and 2 inches in diameter, and are split longitudinally into wedge-shaped segments which are given off in a pinnatifid manner, small fissures appearing in the frond which increase in length, as in *Laminaria digitata*, until a segment is split off; this grows in diameter above the base, remaining narrow below and forming a kind of petiole. Although the structure of the frond resembles that of *Ulva rigida*, C. Ag., its mode of growth is different. Occasionally the frond is perforated in that plant, but the perforations are round, and never split off segments by their enlargement.

PHÆOPHYCEÆ.

GLOSSOPHORA CORIACEA, n. sp.; fronde basi stuposâ, coriaceâ, decomposito-dichotomâ, sinubus rotundatis, segmentis elongato-cuneatis margine integerrimâ, soris frondis basi sparsis.

Hab. Enoura, *Saida*, no. 1.

The plant has the habit of *Dictyota dichotoma*, Lamx., and is apparently at least a foot long when perfect. The substance is coriaceous, and the fronds are blackish when dry. In the transverse section there is an intermediate row of coloured rectangular cells, between the quadrate cortical cells and the large internal hyaline cells, which I have not observed in *D. dichotoma*, Lamx., and which allies it to *Glossophora* rather than *Dictyota*.

DICTYOPTERIS UNDULATA, n. sp. (Pl. VIII. fig. 1); stipite brevi, stuposâ, fronde coriaceo-membranaceâ dichotomâ, sinubus acutiusculis, segmentis patentibus margine eximie undulatâ, minute crenulatâ, rhachide alte stuposâ, robustâ.

Hab. Misaki, *Saida*, no. 91.

This species is distinguished by its small size (not exceeding in the specimen received 4 inches in height), robust rhachis stupose beyond the middle of the frond, and by the densely frilled lamina, which is blackish olive and of firm texture.

PADINA ARBORESCENS, n. sp. (Pl. XII. fig. 1); stipite conico-elongatâ, stuposâ, parce ramosâ, frondibus flabellatis sparse divisis, epruinosis, pergameno-membranaceis, nigrescenti-olivaceis, zonis obscuris.

Hab. Enoshima, *Saida*, no. 84.

This species resembles *Zonaria nigrescens*, Sond., in colour and texture, but it does not present the distinctly parallel lines of cells characteristic of *Zonaria*. The most prominent feature in the plant is the distinct trunk or stem from which the fronds are given off at intervals. This stem is about 1 inch high, forked near the base, each branch bearing about two large and two smaller fronds. The fibrous layer scarcely extends beyond the linear base of each frond. The mature fronds are about 2 inches high and 2 inches broad. The section of the frond shows about six layers of colourless quadrate cells between the upper and lower layer of coloured cortical cells.

Rhodophyceæ.

Amansia multifida, *Lamx.*, var. japonica, n. var.; fronde ramis pinnatis, pyramidatis, inferne tenui-costatâ, ramulis secundariis ejusdem diametro sæpius quadruplo distantibus; colore purpureo.

Hab. Enoshima, *Ohkubo*, no. 17.

The Japanese variety of this plant does not present any very marked characters to separate it from *A. multifida*, Lamx., although the colour is quite different. In the specimen received the nerve is very indistinct, and there are no proliferous branches from the midrib; the secondary branches are less crowded than in the type.

Chondrus elatus, n. sp. (Pl. IX. fig. 1); fronde cæspitosâ lineari, apices versus bis terve furcatâ, ramis obtusis basi attenuatis, a latere sparse proliferis, fructiferis flexuose dilatatis, cystocarpiis in ramos terminales aggregatis, in utrâque paginâ prominentibus.

Hab. Enoshima, *Ohkubo*, no. 30.

The fronds are uniformly 1–1½ lines in diameter, and about 6–8 inches long, rarely branching below the middle. The substance is firm, somewhat rigid, the plants bearing considerable resemblance in form and substance to *Gymnogongrus linearis*; but the branches are more arcuate and divaricate, and the structure is different. The cystocarps are slightly prominent on both sides.

Chondrus ocellatus, n. sp. (Pl. IX. fig. 2); fronde cæspitosâ planâ coriaceâ bis terve furcatâ, sursum margine incrassatâ, segmentis paucis, oblongo-lanceolatis, apice obtusis, cystocarpiis in ramis, numerosis, ocellatis; colore saturate violaceo-purpureo.

Hab. Shimoda, *Saida*, no. 44.

This species is about 2–3 inches high, twice or thrice-forked from near the base, and the segments are divergent at a wide angle, varying from $\frac{1}{4}$–$\frac{1}{3}$ inch in diameter, with rounded axils. At the base the frond tapers to a point, and the branches are slightly constricted at intervals. The cystocarps are surrounded with a raised ring, giving them an ocellate appearance.

Gracilaria Chorda, n. sp.; fronde tereti succulentâ, exsiccatione collabente, submembranaceâ, cartilagineâ, parce dichotomo-racemosa, ramis prælongis simplicibus nudis 2–3-pedalis; sphærosporis cruciatis, in strato corticali nidulantibus; colore purpureo.

Hab. Enoura, *Saida*, no. 6.

This remarkable plant bears a strong resemblance in size and habit to *Chorda Filum*, Stackh. The specimens received are not entire; but, although between 2 and 3 feet long, there are only three branches at the base at intervals of 2 inches apart, one of these being again forked at a distance of 2 inches. The internal cells are proportionately very large. The diameter of the stem when dry is about 1 line.

Gracilaria flexuosa, n. sp.; fronde tereti, filiformi, corneo-cartilagineâ, rigidâ, ad 6 poll. longâ, flexuosâ, alterne pinnatâ, ramis simplicibus, erecto-patentibus, apicibus sæpe divaricatis.

Hab. Shimoda, *Saida*, no. 75.

This species bears considerable resemblance to *G. opaca*, J. Ag.; but it is less branched, and the stem is horny like that of *G. dura*, than which it is more slender. The central cells are much larger than the subcortical cells, which form a tolerably firm and dense layer.

Grateloupia elliptica, n. sp.; fronde carnoso-planâ, cuneato-dilatatâ, repetiter palmatâ, proliferâ, segmentis latis ellipticis obovato-lanceolatisve, dense confertis, chartæ arcte adhærente; colore violaceo-purpureo; sphærosporis cruciatis in strato corticali immersis.

Hab. Enoshima, *Ohkubo*, no. 4.

The specimen received is incomplete at the base; the primary frond bears 4 or 5 large fronds at its apex, which are proliferous from the injured margins and apices; the principal segments are elliptical in outline, 2–3 inches broad and 3–9 inches long. It

becomes much more easily disintegrated in salt water than *G. Ohkuboana*, so that it is almost impossible to remount it without injury. A younger specimen with the base attached, apparently the same species, has the lobes less elliptical and more rounded at the apex.

Grateloupia flabellata, n. sp. (Pl. IX. figs. 3 *a*, 3 *b*.); fronde gelatinoso-membranaceâ, a stipite brevi flabellatim expansâ, segmentis repetiter dichotomis apice subpalmatis obtusis, axillis rotundatis; colore purpureo.

Hab. Enoshima, *Ohkubo*, no. 37.

This plant resembles in form and substance very robust specimens of *G. dichotoma*, J. Ag. The plant is about 2–3 inches high, and 4 inches in width when spread out on paper; and the segments are about $\frac{1}{6}$ of an inch in width, but dilated below the axils; they are more regularly palmate at the apices than in *G. dichotoma*, J. Ag.

Grateloupia acuminata, n. sp. (Pl. X. figs. 2 *a*, 2 *b*, 2 *c*); fronde gelatinoso-carnosâ, latiusculâ, planâ, tripinnatâ, segmentis elongato-ensiformibus longe acuminatis, ciliatis; colore roseo; cystocarpiis nucleo simplici, in strato corticali semi-immersis.

Hab. Enoshima, *Ohkubo*, no. 23.

A large and very beautiful species, probably 18 inches or 2 feet long. The main branches are about $\frac{1}{2}$–$\frac{3}{4}$ inch wide and 12 inches long, the margins being fringed with linear tapering segments about $\frac{1}{3}$ inch apart; these again are ciliated with minute branchlets. The cystocarps, which are small, are scattered all over the older parts of the frond. The structure, in my opinion, bears considerable resemblance to that of *Halymenia latifolia*, and in colour and substance it resembles that genus; but in deference to the much greater experience of Professor J. G. Agardh, who has seen the plant, I have placed it in the genus *Grateloupia*.

Grateloupia furcata, n. sp. (Pl. X. figs. 3 *a*, 3 *b*, 3 *c*); fronde gelatinoso-membranaceâ, repetiter dichotomâ, stipite inferne tereti, mox compressâ expansâ, segmentis inferioribus cuneato-linearibus, superioribus elongatis, ligulatis, tortis vel undulatis ad apices fructus proliferis; colore amethystino-purpureo.

Hab. Shimoda, *Saida*, no. 44.

This species agrees with the description of Mr. Hariot's *Gigartina prolifera*, but the structure of the frond is that of *Grateloupia* rather than *Gigartina*.

It appears to be variable in form, the lower portion consisting of branches only 1–2 lines in width, but the upper portion forms long strap-shaped segments 4–6 inches long and about ⅓ inch wide.

Grateloupia imbricata, n. sp. (Pl. VIII. figs. 2 *a*, 2 *b*.); fronde stipitatâ, compresso-planâ, dichotomo-flabellatâ, segmentis late cuneatis, apice sinuato-lobatis, lobis divaricatis crenatis, eximie nitente, gelatinoso-cartilagineâ, chartæ non adhærente; colore coccineo-purpureo.

Hab. Shimoda, *Saida*, no. 46.

This species belongs to the section *Chondrophyllum*, resembling *G. Cosentinii* in its shining surface and reddish-purple colour. The branches are crowded as in *Rhodophyllis bifida*, the broad form of which it somewhat resembles. If not pruned before mounting, the branches overlap each other, so that it is impossible to show their outline; hence the name *imbricata*.

Grateloupia Ohkuboana, n. sp. (Pl. XI. figs. 1 *a*, 1 *b*); fronde compresso-planâ, a stipite brevissimâ cuneatim dilatatâ, dichotomâ et subpalmatâ, apice proliferâ, segmentis oblongo-lanceolatis; filis interioribus laxe reticulatis; sphærosporis cruciatis, strato corticali immersis; colore coccineo-purpurascente.

Hab. Enoshima, *Ohkubo*, no. 7.

This handsome plant presents a considerable resemblance in form and colour to *Rhodymenia palmata*, Grev., but has a softer and more tender substance, which is easily torn, although more fleshy than in that plant. It apparently reaches a foot or more in length, and the principal segments are about 4-5 inches long and about 1 inch broad. It adheres strongly to paper.

Gymnogongrus divaricatus, n. sp. (Pl. VII. figs. 3 *a*, 3 *b*); fronde carnoso-coriaceâ, compressâ, dichotomo-fastigiatâ, segmentis anguste linearibus eximie divaricatis e ramis inferioribus dense secundatim proliferis; colore roseo-purpureo.

Hab. Shimoda, *Saida*, no. 61 *a*.

This plant is remarkable for being divaricate throughout all its branches, and is yet so fastigiate as to form almost a circle when spread out on paper. The fronds are about ⅔ of a line in width, but are attenuated to half a line in the upper branches.

The tufts are about two inches high, the lower branches purplish red, the upper branches and proliferations pale red. The central cells are oval and rather large for the genus.

GYMNOGONGRUS FURCELLATUS, *Ag.*, var. JAPONICUS, n. var. (Pl. XI. fig. 2); ramis fructiferis corymbosis e margine rhachidis proliferis.

Hab. Enoshima, *Saida*, no. 34.

In this variety the short branches bearing cystocarps are given off from the main stem, below the part where branching commences. They are once or rarely twice forked, forming small corymbs about half an inch in length; the cystocarps are terminal, or immersed in the terminal ramuli in a single row, the portion of the branch where they are formed being dilated to twice its normal width, so that these ramuli appear moniliform.

HYPNEA SAIDANA, n. sp. (Pl. XI. figs. 3 *a*, 3 *b*); fronde compresso-planâ, intricatâ, flexuosâ, parce dichotomâ, ramis alternis secundis ramulis brevibus horizontalibus obsitâ. Fructus non visus. Structurâ *Hypneæ*.

Hab. Enoshima, *Saida*, no. 32.

This plant evidently belongs to the group which contains *H. pannosa.* The branches are intricate and attached at points to each other, and are rather stouter than the majority of species of the genus. The branches when separated are more or less dichotomous, with short, very patent thorn-like ramuli. In appearance it closely resembles the figure given by Martens of *Gelidium aculeatum* ('Die Preussische Expedition nach Ost-Asien,' tab. viii. fig. 4), but I have been enabled, by the courtesy of Major Reinbold, to examine an authentic specimen of Martens's plant, which is evidently a *Gelidium.*

? CHONDRIA CRASSICAULIS, *Harv.* (Pl. VIII. figs. 4 *a*, 4 *b*, 4 *c*).

This species was described by Harvey in the 'Proceedings of the American Academy,' vol. iv. (1859), p. 329, under the name of *Chondria crassicaulis*, but he had apparently not seen either cystocarps or antheridia. My specimens have abundance of antheridia, which appear to be only immersed at the base, not in a terminal cup, but at intervals over the tips of the fronds; they are also more obovate in form and differ entirely in character from those of *Chondria*, in which genus it must, however, provisionally stand until specimens with cystocarps and tetraspores are obtainable. It probably belongs to a new genus.

It differs from the typical species of *Chondria* in the same way that *Champia lumbricalis*, J. Ag., differs from the other species of that genus; the stems being stout and succulent, and the fruiting branchlets arranged in dense fascicles in the axils of the branches.

Hab. Enoshima, *Saida*, no. 26; *Ohkubo*, no. 29.

POLYZONIAS FISSIDENTOIDES, n. sp. (Pl. XII. figs. 2 *a*, 2 *b*); fronde basi parce ramosâ, ramis alternis, foliis alternis, distichis, subdecurrentibus, utrinque integerrimis, lineari-lanceolatis acutis, paginâ transverse zonatâ. Fructibus non visis.

Hab. Enoshima, *Ohkubo*, no. 16.

Parasitical on other algæ.

The only specimen received is about ½ inch long, slightly branched at the base, and at the height of about ¼ inch exhibits an interruption of growth, the leaves becoming smaller and enlarging again above the interruption. The leaves are quite distinct from those of any other known species, being narrowly lanceolate and acute, and the cells form short tubes arranged in rows, in this point resembling *P. jungermannioides*, J. Ag. The nearest species in form is *P. ovalifolia*, Hook. et Harv., but this has the upper margins of the leaves serrate and the cells hexagonal. The plant is so like a *Fissidens* in habit, that the name *fissidentoides* seems peculiarly appropriate.

APPENDIX I.

British Marine Algæ occurring also in Japan.

CYANOPHYCEÆ.

- *Dermocarpa Schousbæi, *Born.*
- *Lyngbya confervoides.

CHLOROPHYCEÆ.

- Chætomorpha crassa.
- Cladophora gracilis.
- Codium tomentosum.
- Enteromorpha complanata.
- „ crinita.
- „ ramulosa.
- „ Linza.
- Ulva latissima.

PHÆOPHYCEÆ.

- Asperococcus bullosus.
- Castagnæa divaricata.
- Chorda Filum.
- Chordaria flagelliformis.
- Desmarestia viridis.
- Dictyota dichotoma.
- Dictyopteris polypodioides.
- Laminaria flexicaulis, *Le Jol.*
- „ saccharina.
- Leathesia tuberiformis.
- Padina pavonia.
- Scytosiphon lomentarius.

* In the collection received by me, *Dermocarpa* is parasitical on the *Lyngbya*. These were determined at my request by M. Maurice Gomont.

RHODOPHYCEÆ.

Callymenia reniformis.
Catenella Opuntia.
Ceramium rubrum.
Chondria tenuissinia.
„ dasyphylla.
Chondrus crispus.
Chylocladia kaliformis.
Corallina mediterranea.
Fastigiaria furcellata.
Gelidium corneum.
Gigartina acicularis.
Gloiosiphonia capillaris.
Gracilaria confervoides.
Grateloupia filicina.
Griffithsia corallina.
Gymnogongrus patens.
Halurus equisetifolius.
Halymenia ligulata.
Laurencia obtusa.
„ pinnatifida.
Melobesia corticiformis, *Kuetz.*
„ membranacea.
„ pustulata.
Polysiphonia elongella.
Pterocladia capillacea.

APPENDIX II.

Having had occasion to write to Herr Grunow concerning an unpublished species of his, a *Grateloupia* from Japan, with which I considered one of my specimens to be identical, he kindly forwarded for publication, as an Appendix to my paper, his description of the plant in question together with those of some other Japanese species which he had in hand. These species are as follows:—

GRATELOUPIA GELATINOSA, *Grun.* (Pl. XII. fig. 3); fronde pulvinatâ, crassiusculâ, repetite dichotomâ, laciniis linearibus, apicem versus sublatioiibus dichotomis angulo subacute separatis, tribus, quaternis vel quinis, ultimis rotundatis; prolificationibus lateralibus nullis; tetrasporis auguste lineari-oblongis favellis (raris) parvis, subglobosis, in segmentis penultimis et antepenultimis vix dispositis; planta parva in aquâ dulci cito deliquescens.

Hab. ad litora Japoniæ (*Tanaka*, nos. 7, 20, and 37, in Herb. Mus. Vindob.)

The specimens examined are 2½–4 cm. high and up to 4 mm. broad, of a dirty dark violet colour, and easily softening into a jelly in fresh water. It somewhat resembles *G. dichotoma*, but that species is less easily softened in fresh water, and is always more or less furnished with lateral proliferations and has acute apices. It varies, however, exceedingly in size, from scarcely a millimetre broad to very broad with numerous proliferations, so as to often approach *G. Cosentinii*, Kuetz. (*G. Proteus*, Kuetz.). Possibly the following may be only forms of *G. dichotoma*, but I have for the present given them specific rank.

Grateloupia (dichotoma, var.?) japonica, *Grun. in litt.* (Pl. XII. fig. 4.); fronde *Gr. dichotomæ* simili, subcartilagineâ, humili, pulvinatâ, segmentis magis patentibus, apicibus obtusis fastigiatis, prolificationibus nunc raris vel nullis, nunc creberrimis.

Hab. ad litora Japoniæ (*Tanaka*, in Mus. Vindob. no. 25).

The specimens are about 2½ cm. high and 1½ cm. broad, brownish violet or greenish. The cortical layer consists of a longer series of cells than in *G. dichotoma,* especially in the tetrasporic individuals. The filaments of the inner layer evidently anastomose. Dr. J. Agardh, to whom I sent this plant, in his 'Beiträge zur Systematik der Algen,' considered it might belong to his *G. fastigiata* from the Sandwich Isles. *G. emarginata,* Kuetz., from New Caledonia, appears to be a similar plant.

G. (dichotoma, var.?) acutiuscula, *Grun.* (Pl. XII. fig. 5); fronde humili, *dichotomæ* simili, irregulariter dichotomâ, segmentis ultimis acutiusculis, pulvinatâ, subcartilagineâ, sæpe prolificationibus lateralibus creberrimis obsessâ; colore obscure fusco-olivaceo.

Hab. ad litora Japoniæ (*Tanaka,* Mus. Vindob. no. 14).

The plant is about 4 cm. high and 2 mm. broad. Very like *G. japonica,* Grun., but differing in the pointed apices.

Nemaleon pulvinatum, *Grun. in litt.* (Pl. XII. fig. 6); fronde pumilâ, pulvinatâ, irregulariter dichotomâ, ramosissimâ, teretiusculâ, segmentis patentibus ultimis obtusiusculis; colore obscure fusco-olivaceo; fructificatio? Structurâ *Nemalionis.*

Hab. ad litora Japoniæ (*Tanaka*, no. 13 in Mus. Vindob.).

This species forms little cushions 1½ cm. high, very branched, with ½ mm. thick, blackish olive-green, squarrose, dichotomous branchlets. The structure is that of *Nemaleon.*

EXPLANATION OF THE PLATES.

Plate VII.

Fig. 1 *a. Codium cylindricum,* nat. size. 1 *b.* Utricle, magnified.
2 *a. Codium divaricatum.* 2 *b.* Utricle, magnified.
3 *a. Letterstedtia japonica,* portion of frond, nat. size. 3 *b.* Vertical section of frond, magnified; 3 *c,* more magnified; 3 *d,* surface view of cells.

PLATE VIII.

Fig. 1. *Dictyopteris undulata*, nat. size.

2 *a*. *Grateloupia imbricata*, portion of frond, nat. size. 2 *b*. Transverse section of frond, magnified.

3 *a*. *Gymnogongrus divaricatus*, portion of frond, ⅔ nat. size. 3 *b*. Transverse section of frond, magnified.

4 *a*. ? *Chondria crassicaulis*, Harv., portion of frond, nat. size, bearing antheridia. 4 *b*. Transverse section of stem. 4 *c*. Antheridia *in situ*, magnified.

PLATE IX.

Fig. 1 *a*. *Chondrus elatus*, nat. size, with cystocarps. 1 *b*. Transverse section of frond.

2 *a*. *Chondrus ocellatus*, nat. size. 2 *b*. Transverse section of frond, magnified. 2 *c*. Section of frond through a cystocarp, magnified.

3 *a*. *Grateloupia flabellata*. 3 *b*. Transverse section, magnified; 3 *c*, more magnified, showing cruciate tetraspores *in situ*.

PLATE X.

Fig. 1. *Cladophora Ohkuboana*.

2 *a*. *Grateloupia acuminata*. 2 *b*. Transverse section of frond showing cystocarp. 2 *c*. Portion of ditto, enlarged.

3 *a*. *Grateloupia furcata*, nat. size. 3 *b*. Transverse section, magnified.

PLATE XI.

Fig. 1 *a*. *Grateloupia Ohkuboana*, nat. size. 1 *b*. Transverse section of frond, magnified.

2. *Gymnogongrus furcellatus*, var. *japonicus*, portion of frond, nat. size.

3 *a*. *Hypnea Saidana*, portion of frond, nat. size. 3 *b*. Transverse section of frond, magnified.

PLATE XII.

Fig. 1. *Padina arborescens*, nat. size.

2 *a*. *Polyzonias fissidentoides*, nat. size. 2 *b*. Portion of frond, magnified.

3. *Grateloupia gelatinosa*, nat. size.

4. *Grateloupia japonica*, nat. size.

5. *Grateloupia acutiuscula*, nat. size.

6. *Nemaleon pulvinatum*, showing a branched filament, magnified.

K.H. del

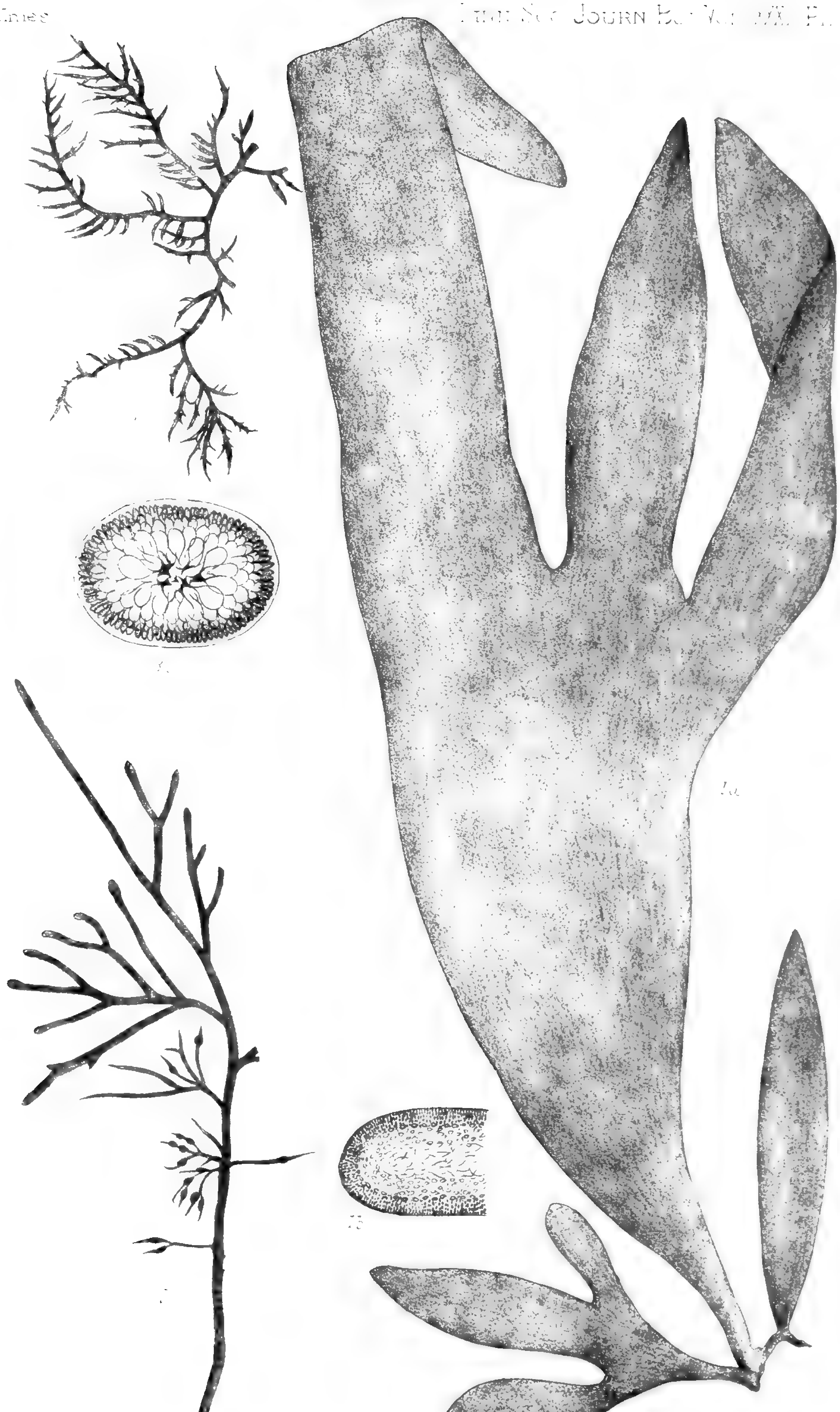
1 CODIUM CYLINDRICUM 2 C DIVARICATUM
3 LETTERSTEDTIA JAPONICA

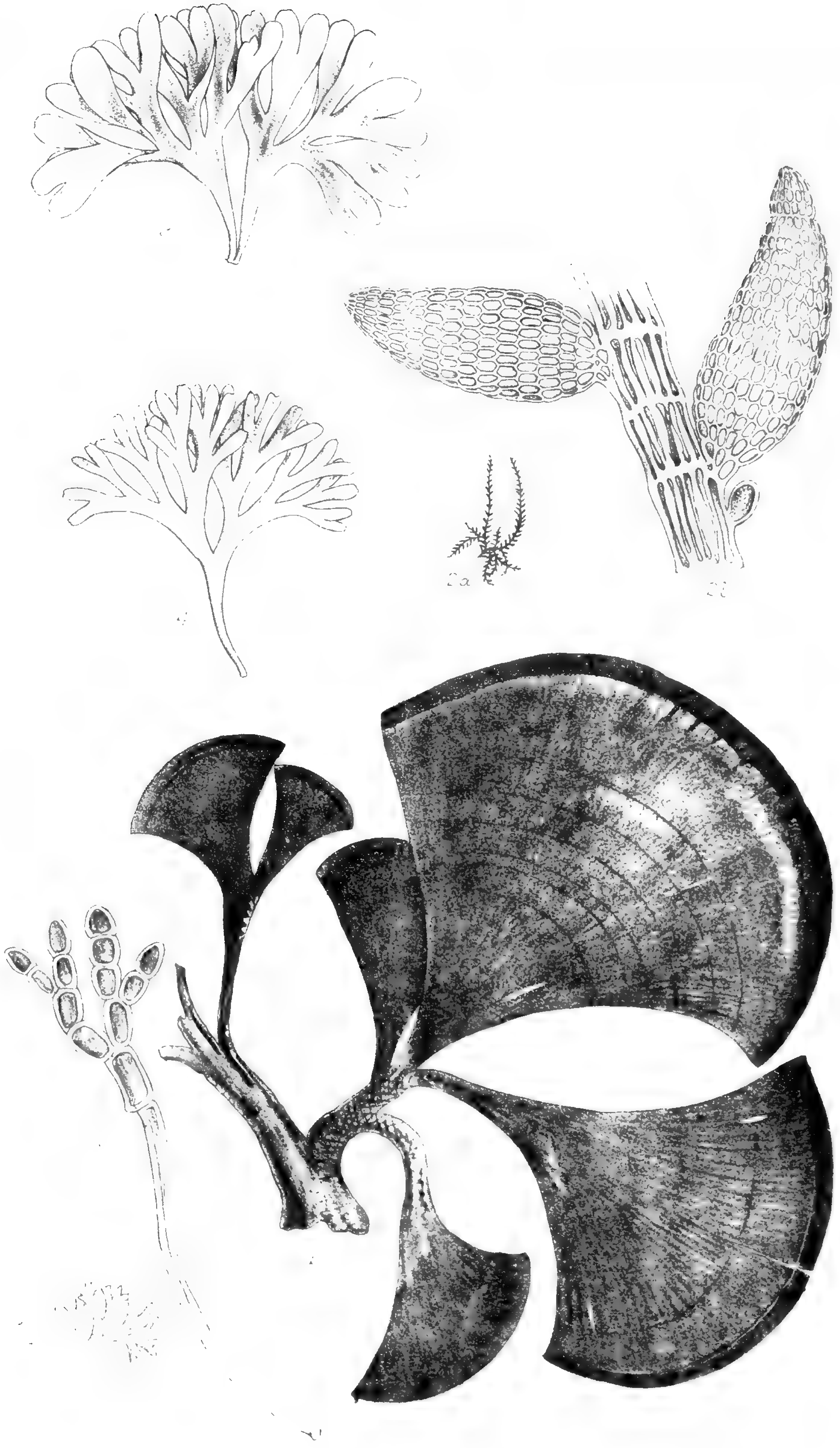
1 [illegible] YOPTERIS UNDULATA. 2 GRATE[illegible]IA [illegible]
3 GYMNOGONGRUS [illegible] 4 [illegible]

CHONDRUS ...
GRA... ...

K. H. del.

1. CLADOPHORA ...
2. GRATELOUPIA AC...





An Enumeration of all ORCHIDEÆ hitherto recorded from Borneo.

By H. N. RIDLEY, M.A., F.L.S.

[Read 21st December, 1893.]

(PLATES XIII.–XV.)

FEW countries so rich in Orchids as Borneo have been so much neglected in the elucidation of these plants, although a considerable number of the showier kinds have been introduced and described in various horticultural periodicals. Unfortunately the localities given in these publications are nearly all worthless, owing to the desire of the introducers to keep the localities secret whence they were procured. I have had the gratification of working through the important collections made by Dr. Haviland in the neighbourhood of Sarawak, and the plants in this collection form the basis of my remarks; to which I have added description and notes of species collected in Sarawak by Bishop Hose, and in Sandakan by Mr. Pryer, together with a few obtained from various other collectors and orchid dealers in Singapore, and there cultivated in the Botanic Gardens. Many of the latter are described from living plants, which must be taken into account when comparing the descriptions with dried specimens. In the list I have incorporated the names of species recorded from Borneo which there is reason to believe were really obtained there.

It will be noticed that there is a preponderance of *Epidendreæ*, due to the prominence of the large genera *Eria*, *Dendrobium*, and *Bulbophyllum*. *Neottieæ* are not well represented; but I believe that careful searching will produce a considerable number. Always difficult to find in the dark recesses of the jungle, seldom met with in flower, and difficult to bring home alive, they are more likely to be neglected than the more conspicuous epiphytes easily brought down and cultivated.

The most interesting plant in the list is the new genus *Porphyroglottis*, allied to *Chrysoglossum*, but with the habit of *Grammatophyllum*.

There are a considerable number of species common to Borneo and the Malay peninsula, and very nearly all the Bornean genera are represented in the latter region; but certain genera, such as *Phalænopsis*, *Platyclinis*, and *Cypripedium*, are more abundant in Borneo, probably from local causes.

Taking it as a whole, the Malayan region, from the Isthmus

of Kra to Java inclusive, is, as regards Orchids, at least tolerably homogeneous. The *Dendrobia*, among others, mark off the Malayan regions very distinctly. In India and Siam occur the sections *Stachyobium* and *Eudendrobium*, with the great section of *Speciosæ* (e. g. *D. nobile*, Lindl., *D. aggregatum*, Roxb.). These are nearly absent from the Malayan region, of which the most characteristic sections are *Aporum*, *Strongyle*, *Cadetia*, *Pedilonum*, and *Distichophyllæ*. In the Papuan region occurs the *Taurinum* section with twisted petals, quite absent from the Malayan region. The most characteristic genera of the Malay region are *Platyclinis*, *Dendrochilum*, *Nephilaphyllum*, *Thelasis*, *Microsaccus*, *Adenoncos* (*Sarcochilus*), *Appendicula*, *Podochilus*, and *Plocoglottis*.

The Orchids of the highest ranges of Mt. Kinabalu are typically Malayan. There is nothing to show any connexion with the Himalayan flora; though from the other plants collected by Dr. Haviland and the fauna obtained there, it appears that there is a decided trace of a Himalayan element. I have added some notes on the *Apostasiaceæ*, not because I consider them to bear close relationship to the Orchids, but rather for convenience, since it is usual for botanists to look for accounts of these plants under *Orchideæ*.

Epidendreæ.

Oberonia ciliolata, *Hook. f. Fl. Brit. Ind.* vi. p. 181. Sitam; Sarawak (*Dr. Haviland*).

O. multiflora, sp. nov.

Cæspitosa, subacaulis. Folia pauca, falciformia, acuta, 2 pollices longa, $\frac{1}{4}$ poll. lata. Racemus gracillimus ad 3 pollices longus, floribus plurimis conspicue verticillatis minutis. Bracteæ pallidæ, lanceolatæ, acuminatæ. Sepala lanceolata acuta. Petala minora lanceolata. Labellum trilobum, lobis lateralibus ovato-lanceolatis, subfalcatis, acutis, medio latiore obcuneato, apice lato sinuato subemarginato aurantiaco. Capsula $\frac{1}{16}$ poll., subglobosa.

Trusan River (*Haviland*!).

This is chiefly remarkable for the minuteness of its flowers, which are much smaller than those of most Oberonias. It really belongs to the *Caulescentes*, though the stem is very short.

OBERONIA SINUOSA, sp. nov.

Caules plures elongati sinuati, 7-pollicares, complanati, $\frac{1}{4}$ poll. lati. Folia plurima ad 19, laminis ensiformibus acutis brevibus, $\frac{1}{2}$ poll. longis, erectis, falcatis. Racemus ad 4 poll. longus. Flores perparvi verticillati, verticillis approximatis rubri. Bracteæ oblongæ acutæ, obscure denticulatæ. Sepala brevia, oblonga subobtusa. Petala linearia, omnia recurva. Labellum angustum, porrectum, elongatum, lineare, apice bifido, laciniis angustis linearibus acutis, fovea perparva. Columna pro genere longiuscula. Capsula elliptica, $\frac{1}{8}$ poll. longa, pedicello $\frac{1}{16}$ poll.

Sarawak, Kuching (*Bishop Hose* ! *Dr. Haviland* !).

A very distinct species in its long narrow wavy stems, with the laminæ of the leaves very short, and remarkable, too, for its long narrow lip bifid at the apex.

O. MACROSTACHYS, sp. nov.

Caulescens. Caules 6–12-pollicares, flexuosi, lati. Folia ensiformia acuta, subpatula, 2 pollices longa, $\frac{1}{2}$ poll. lata. Racemus validus 6-pollicaris. Bracteæ lanceolatæ acutæ, integræ. Flores copiosi haud verticillati, pedicellis longiusculis, ovariis pubescentibus. Sepala late ovata, brevia. Petala ovata, minora. Labellum breve, foveâ magnâ, basi angustâ crassâ, apice dilatato rotundato, laciniato, laciniis obtusis oblongis. Capsula elliptica ovata, ferme $\frac{1}{4}$ poll.

Braang; limestone rocks at 1400 feet elevation (*Haviland* !).

O. LOBBIANA, *Lindl. Fol. Orch. Ober.* p. 7. Collected in Borneo by Lobb. I have not again met with it.

MICROSTYLIS METALLICA, *Reichb. f. in Gard. Chron.* (1879) II. p. 750. Sarawak (*Dr. Haviland*).

M. CALLOPHYLLA, *Reichb. f. l. c.* p. 718. Penokok, Kinabalu, at 3000 feet alt. (*Dr. Haviland*).

M. COMMELYNIIFOLIA, *Zoll. & Mor. in Nat. en Geneesk. Arch. Neêrl. Indie,* (1844) i. p. 402. Sarawak (*Dr. Haviland*).

M. CHLOROPHRYS, *Reichb. f.* ? *in Gard. Chron.* (1881) I. p. 266. Braang (*Dr. Haviland*).

M. MACULATA, sp. nov.

Rhizoma repens, caules pollicares. Folia tenuia maculata ovata acuta, inæqualia, margine crispo, 2 pollices longa, $1\frac{1}{2}$ poll.

lata, nervis 5 conspicuis, petiolis ultra dimidium pollicis longis. Racemus 3-pollicaris angulatus. Flores dissiti, iis *M. metallicæ* æquales. Pedicelli ½ poll. longi, tenues. Bracteæ lanceolatæ acuminatæ, deflexæ, ¼-pollicares. Sepala oblonga obtusa. Petala linearia obtusa. Labellum obovatum oblongum, auriculis ovatis obtusis, apice lato rotundato denticulato, denticulis brevibus obtusis, carinâ transversâ ad basin laminæ, venis incrassatis medianis 3. Columna longiuscula, stelidiis majusculis obtusis.

Dulit (*C. Hose*). "Flowers purple, leaves spotted."

An ally of *M. metallica*, Reichb. f., differing in its thinner, more acute crisped leaves, broader sepals and petals, and more oblong lip, with shorter and blunter auricles.

MICROSTYLIS ELEGANS, sp. nov.

Caules vix incrassati (ex sicca) 1½-pollicares. Folia dissita, inæqualia, ovata lanceolata, acuta, crispula petiolata; lamina majoris 1½ pollices longa, ¾ poll. lata, petiolo ferme pollicari. Scapus ad 4 pollices longus, *gracilis*, basi bracteis paucis exceptis nudâ. Racemus laxus, ad 20-florus. Bracteæ lanceatæ acutæ, deflexæ, 1/16-pollicares. Pedicelli graciles, patentes, filiformes, ⅜-pollicares. Flores iis *M. metallicæ* æquales. Sepala angusta, oblongo-linearia, ⅛-pollicaria. Petala linearia. Labellum *ovatum* obtusum, auriculis longis triangulari-ovatis acutis; *lamina ferme integra, dentibus* 2–3 brevibus in utroque latere versus apicem. Columna stelidiis cornutis curvis.

Sarawak (*Haviland*!).

M. LACINIOSA, sp. nov.

Vix bulbosa, caulis pollicaris. Folia ad 4 inæqualia ovata, 1¾ poll. longa, pollicem lata, subobtusa; nervis 3 conspicuis. Scapus gracilis 6-pollicaris, basi nudus, bracteis lanceolatis acuminatis dissitis ¼ poll. longis exceptis. Racemus tripollicaris. Flores parvi, subdissiti, plures. Bracteæ lineares acutæ deflexæ, pedicellis ⅛-pollicaribus subæquales. Sepala ovata obtusa. Petala lineari-lanceolata obtusa. Labellum ovatum, latum. Auriculis longis acutis; *lamina ad apicem multi-laciniata*. Columnæ stelidia obtusa.

Trusan River, at 600 feet elevation (*Haviland*).

Near *M. metallica*, Reichb. f., but with the apex and sides of the lip laciniate.

LIPARIS MONTANA, *Lindl. Gen. et Sp. Orch.* p. 29; var. MAXIMA.

Caulis elatus ad 4-pollicaris, validulus, vaginis tenuibus tectus.

Folia circiter 4 congesta ad apicem ovata vel ovato-lanceolata, tenuia, acuminata, inæquilatera, 5 pollices longa, 2-3 pollices lata. Scapus 6-pollicaris validulus. Flores iis *Liparidis montanæ*, Blume, similes, sed majores. Labellum $\frac{1}{4}$-pollicare.

Trusan River (*Haviland* !).

This plant appears to me to differ from *Liparis montana*, Lindl., only in size. It has rather the habit of *L. Wightiana*, Thw.

LIPARIS LACERATA, *Ridl. in Journ. Linn. Soc.* (*Bot.*) xxii. (1886) p. 284. Selabat; Matang; Kuching (*Haviland*). Lawas River (*Burbidge*).

L. LATIFOLIA, *Lindl. Gen. et Sp. Orch.* p. 30. Trusan River (*Haviland*).

L. GRANDIFLORA, *Ridl. in Journ. Bot.* xxii. (1886) p. 333. Mindai-Pramassan (*Grabowsky* !). Sarawak (*Everett* !).

L. FLACCIDA, *Reichb. f. in Linnæa*, xli. (1877) p. 45. Kuching (*Haviland*).

L. ELEGANS, *Lindl. in Wall. Cat.* n. 1943; *Gen. et Sp. Orch.* p. 30. Sarawak.

L. DISTICHA, *Lindl. in Bot. Reg.* sub t. 882. Limestone rocks, Sarawak (*Haviland*).

L. (§ DISTICHÆ) ARANEOLA, sp. nov.

Pseudobulbi ovales, compressi, $\frac{3}{8}$ poll. longi, $\frac{3}{8}$ poll. lati, $\frac{1}{8}$ crassi. Folium 6 pollices longum, $\frac{3}{8}$ poll. latum, lineare acutum, subcoriaceum. Scapus folio æqualis complanatus anceps, racemo $\frac{3}{4}$-pollicari mutanti. Bracteæ distichæ, $\frac{1}{4}$-pollicares, equitantes. Flores pedicellis $\frac{3}{8}$-pollicaribus erecti, *pallide virides*. Sepala *lata oblonga obtusa* deflexa, $\frac{1}{4} \times \frac{1}{8}$, pallide flavescentia. Petala erecta *oblanceolata*, vix $\frac{1}{4}$ poll. longa. Labellum breve, ungue brevissimo, *callo paullo elevato trilobo*; lamina subtriloba, marginibus ad basin incrassatis, erectis, flavis; lobo medio ovato acuto pallido. Columna crassa, lata, marginata; stelidiis brevibus distinctis. Anthera complanata, ovata. Pollinia 4, parallella, oblonga.

Borneo, Pontianak (cult. in Hort. Bot. Singapore).

Closely allied to *L. disticha*, Lindl., but differing in the broader, blunter, deflexed sepals, broad oblanceolate, not linear petals, the form of the lip, and the pale greenish colour. The lip, as in *L. disticha*, Lindl., is abruptly bent down on the short

claw, and the base just above the claw is pinched up into two rounded ears; in front of this again the blade is pinched in, so that the lip from in front looks as if it were three-lobed, with two thickened erect lobes of a bright honey-yellow, with an ovate shortly clawed mid-lobe of a pale whitish yellow. The calli much resemble those of *Liparis disticha*, Lindl., three raised lumps from the spaces between which run two low ridges. The column has the broad shape of *L. disticha*, Lindl., with sharp edges; the stelidia (wings of column) run down the inner face along the stigma, which they partially conceal.

PLATYCLINIS LONGIFOLIA, *Hemsl. in Gard. Chron.* (1881) II. p. 656. Braang (*Haviland*).

This is the common species in Singapore and the southern part of the Malay peninsula.

P. SIMILE, *mihi*, var. ?—Dendrochilum simile, *Blume*. Sarawak (*Haviland*).

This plant differs from a specimen collected by Beccari in Sumatra (no. 378) in the absence of the teeth on the lateral lobes.

P. GRANDIFLORA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 233. Kinabalu, ad 10,500 pedes alt. (*Haviland*).

P. GLOBIGERA, sp. nov.

Rhizoma gracile, pseudobulbis globosis, $\frac{1}{4}$-pollicaribus, flavis, corrugatis (ex sicco). Folium lanceolatum petiolatum obtusum, laminâ 2 poll. longâ, $\frac{1}{2}$ poll. latâ, petiolo $\frac{1}{2}$-pollicari; nervis elevatis 5. Scapus folium vix superans erectus, $2\frac{3}{4}$-pollicaris, gracilis. Racemus ad 16-florus, floribus parvis. Bracteæ lanceolatæ obtusæ, pedicellis ovaria æquantes. Sepala lanceolata acuminata, carinata, $\frac{1}{4}$-pollicaria. Petala oblonga elliptica obtusa, carinata, sepali dimidio æqualia. Labellum oblanceolatum panduratum obtusum, lobis lateralibus vix distinctis, erectis, carnosulum, petalis subæquale, nervis tribus mediis incrassatis. Columna petalis brevior, basi angustata superne incrassata, margine dorsali clinandrii ovato-obtuso denticulato; brachia lanceolata acuminata e lateribus columnæ juxta stigma exorta. Anthera galeata, dorso excavato.

Epiphytica, ad apicem montis Serapi (*Haviland*).

P. CORRUGATA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* (1894) p. 233. Kinabalu, Mari-pari, ad 5500 pedes alt. (*Haviland*).

PLATYCLINIS STACHYODES, *Ridl. l. c.* p. 234. Kinabalu, 11,000 pedes alt.

P. SARAWAKENSIS, sp. nov.

Pseudobulbi oblongi, rugosi, $\frac{3}{4}$ poll. longi, $\frac{1}{4}$ crassi. Folium coriaceum, 7 poll. longum, lanceolatum, subpetiolatum, petiolo pollicari, laminâ atro-viridi, obtusâ, $\frac{1}{2}$ poll. latâ. Scapus ex axillâ, folio juveni ultra 8-pollicari gracillimo, racemus decurvus multiflorus; flores iis *P. latifolii* æquales, $\frac{1}{4}$ poll. lati; vaginæ vacuæ paucæ ad basin racemi. Bracteæ siccæ, lanceolatæ acutæ, pedicello æquales, $\frac{1}{4}$-pollicares. Sepala lanceolata acuta, petala sublanceolata subobtusa, omnia flavescenti-viridia. Labellum sepalis brevius, lobis lateralibus brevibus subquadratis obscure denticulatis, lobo medio deflexo, oblongo-ovato, breviter cuspidato; carina mediana inter lobos, lateribus incrassatis, obscurius viridis. Columna breviuscula, clinandrio dilatato cucullato, marginibus integris. Stelidia brevissima, lata, denticulata. Anthera lata galeata apiculata, margine lato. Rostellum elongatum, tenue quadratum. Stigma ovale, marginibus incrassatis.

Sarawak (coll. Rev. Biggs; cult. in Hort. Bot. Penang).

Allied to *P. simile*, Ridl., but differing in its stelidia, which are very short quadrate broad processes, not reaching even as far as the stigma, and toothed at the apex.

DENDROBIUM (§ SARCOPODIUM) TREACHERIANUM, *Reichb. f., ex Hook. f. Bot. Mag.* t. 6591. Pontianak.

D. LABUANUM, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 6, "Borneo, *Lobb*." This I have not seen.

D. LONGICOLLE, *Lindl. Bot. Reg.* (1840), *Misc.* p. 74. Sarawak (*Bishop Hose*).

This plant does not, as suggested in the 'Flora of British India,' bear more than one leaf on each pseudobulb; but above this there is a brown sheathing bract which enwraps the pedicel of the flower, which is usually, but not always, solitary. The pseudobulbs are densely crowded on the rhizome.

D. KINABALUENSE, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 234. Kinabalu, 7000 ped. alt., epiphytica (*Haviland*).

D. (§ BOLBODIUM) PUMILUM, *Roxb. Hort. Beng.* p. 63; *Fl. Ind.* iii. p. 479. Sarawak (*Bishop Hose*).

D. (§ NIGROHIRSUTÆ) SCULPTUM, *Reichb. f. in Bot. Zeit.* xxi. (1863) p. 128. Borneo.

DENDROBIUM LOWII, *Lindl. Gard. Chron.* (1861) p. 1046. N.W. Borneo (*Low, &c.*)

D. SPECTATISSIMUM, *Reichb. f. in Linnæa*, xli. (1877) p. 41. Borneo (*Lobb*).

D. (§ STRONGYLE) SUBULATUM, *Hook. f. Fl. Brit. Ind.* v. p. 726. Sarawak (*Haviland*).

D. ACEROSUM, *Lindl. Bot. Reg.* (1841), *Misc.* p. 43. Occurs in Borneo according to the 'Flora of British India.'

D. (§ CADETIA) EUPHLEBIUM, *Reichb. f., ex Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 7. Sarawak, limestone rocks (*Haviland*).

This plant, though not recorded from the Malay peninsula in the 'Flora of British India,' is by no means rare in Singapore, growing on the Mangroves at Kranji and elsewhere; and I have found it, too, on trees on the top of the mountain Gunong Panti in Johore.

D. KUNSTLERI, *Hook. f. Fl. Brit. Ind.* v. p. 714. Kuching, Sarawak (*Haviland* !)

D. (§ BREVIFLORES) MICROGLAPHYS, *Reichb. f. in Gard. Chron.* (1868) p. 1014. Borneo (*Low*).

It is said to be allied to *D. aduncum*, Wall.

D. (§ APORUM) ATROPURPUREUM, *Miq. Fl. Ind. Bat.* iii. p. 644. Sarawak (*Bishop Hose* !).

D. EULOPHOTUM, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 5. Sarawak (*Bishop Hose* !).

D. LEONIS, *Reichb. f. in Walp. Ann.* vi. p. 280. Limestone rocks, Sarawak (*Haviland* !).

D. GRANDE, *Hook. in Fl. Brit. Ind.* v. p. 724. Pengkulu Ampat (*Haviland* !).

D. SERRA, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 3. Sarawak (*Bishop Hose* !). Kapoeas (*Teysman in Herb. Bogor.*).

D. ROSELLUM, sp. nov.

Caules erecti vel suberecti, ramosi, ultra 12 pollices longi. Folia ovate coriacea atro-viridia acuta striolata subremota, $\frac{1}{2}$–$\frac{3}{4}$ poll. longa, $\frac{3}{4}$ poll. lata. Capitula ex apicibus nudis caulium exorta (ut in *D. Serra*, Lindl.). Bracteæ plures, bruneæ. Flores *rosei*, $\frac{3}{8}$ poll. longi. Sepalum posticum ovatum parvum, lateralia latiora; mentum longum rectum, apice

incrassato, album. Petala sepalis minora, ovata lanceolata, rosea. Labellum longum angustum, basi rectum loratum, vix trilobum, *apice obovato profunde bilobo, lobis rotundatis.* Callus *medius oblongus* flavus, in medio canaliculatus, ad basin laminæ, omnino roseus margine et maculâ juxta callum albâ exceptis. Columna longa et pro genere gracilis; stelidiis brevibus; ventre canaliculato, albo, lateribus roseo pictis. Anthera plana in clinandrio profundo immersa. Pollinia 2 valde cerea et polita acinaciformia canaliculata. Stigma oblongum.

Trunk of a fallen tree, Selabat (*Haviland!*).

I have had this species in cultivation for a considerable time, labelled Singapore; but, except in one other garden, I have not found it growing anywhere in the Peninsula. In the dry state it much resembles *D. Serra,* Lindl., and has probably been passed over for that species. But the latter has the flowers always white, much smaller, and the terminal lobe of the lip, which in *D. rosellum* is broad and rounded, broader than the rest of the lamina, in *D. Serra,* Lindl., is represented by the two short, narrow, parallel lobules.

DENDROBIUM (§ VIRGATÆ) PINIFOLIUM, sp. nov.

Caules 6–8 pollices longi, *basibus gracilibus* superne paullo incrassati, internodiis bruneis, pollicem longis, ½ poll. latis, *canaliculatis bruneo-tomentosis.* Folia *linearia acuta angustissima* carnosa, atro-viridia, canaliculata. Racemus *brevissimus,* triflorus. Flores pollicem longi, pedicellis ¾ poll. longis. Sepalum posticum lanceolatum obtusum, lateralia latiora; mentum sepalo æquale, rectum pendulum obtusum. Petala *linearia* angusta, omnia carnea, nervis obscurioribus. Labellum album *spathulatum,* lobi laterales obtusi rotundati, *lobus medius ovato-reniformis profunde retusus* pallide aurantiacus, *nervis elevatis tribus in disco connatis* ad apices distinctis, obtusis, ad basin lobi medii terminatis pallide ochreis, lineâ medianâ aurantiacâ. Columna rosea, elongata, gracilis. Anthera obtusa, crassa, papillosa. Stigma rotundatum margine elevato.

Sandakan (*Pryer*). *V. v.*

A curious plant with the channelled stem of one of the *Distichophyllæ,* narrow fleshy leaves, and a few rather small flesh-coloured flowers. I believe it to belong to the *Virgatæ* section, and to be allied to *D. villosulum,* Wall.

D. VILLOSULUM, *Wall. Cat.* n. 2006. Matang, 2000–3000 ped. alt.! Kinabalu, Penokok, 3500 alt. (*Haviland*).

This is common on dry spots at about 2000 feet on Mt. Ophir, and occurs too in the low country in Singapore. I imagine *Dendrobium attenuatum*, Lindl. in Journ. Linn. Soc. (Bot.) iii. (1859) p. 17, is intended for this species. It was based on a plant collected in Borneo by Lobb, and no. 482 of his collection is certainly this. I suspect also *D. Lobbii*, Teysm. and Binn., "Singapore, Lobb," is the same.

DENDROBIUM CRUMENATUM, *Sw. in Schrad. Journ.* ii. (1799) p. 237. Sarawak (*Hose*!).

D. (§ VIRGATÆ) SETIFOLIUM, sp. nov.

Caules congesti, penduli, pedales *gracillimi, internodio unico ad basin incrassato fusiformi*, pollicem longo, ½ poll. crasso, olivaceo (sicco corrugato flavo). Folia *setacea* canaliculata, 3 pollices longa, acuta, remota. Racemus *brevissimus*, ⅛ poll. longus, bracteis siccis bruneis tectus (ut in sectione *Aporo*) lateralis. Flores singulatim expansi, parvuli. Pedicellus ⅜ poll. longus. Sepala lanceolata, ferme ½-pollicaria, lateralia paullo latiora subacuta. Petala linearia erecta, omnia alba. Mentum sepalo æquale, curvum obtusum. Labellum *trilobum, lobi laterales majusculi rotundati*, albi intus venis rubris ornati; *lobus medius ovatus*, unguiculatus, albus; fascia in disco inter lobos laterales elevata, apice rotundata denticulata flava, supra basin lobi medii projecta. Columna recta angusta, stelidiis dentiformibus erectis antheram superantibus, ventre excavato canaliculo, basi latiore, superne attenuato. Anthera depressa, obtusa. Stigma ellipticum. Rostellum retusum.

Sarawak (*Haviland*!). Rhio (*native collector. V. v.*!).

This has long been in cultivation in Singapore.

It is evidently allied to *D. aciculare*, Lindl. The stems are very slender, except towards the base where there is a dilated fusiform internode. The leaves very thin and slender, terete, except for the groove above. The flowers appear one at a time from a tuft of dry brown bracts about halfway up the stem. They are thin textured and rather fugacious; white, except for the pink and yellow marks on the lip; the lateral lobes are blunt and rounded, broadest at the apex, the mid-lobe ovate. A raised bar runs down the middle of the disc between the lateral lobes and ends in a rounded obtuse callus, which is very finely notched; it projects over the base of the middle lobe, so that the latter appears to rise from beneath it. The column has a kind of channel rising from the base and narrowing upwards.

DENDROBIUM (§ DISTICHOPHYLLÆ) OVATIFOLIUM, sp. nov.

Caulis *crassus, ultra tripedalis*, $\frac{1}{4}$ poll. crassus (in sicco subquadrangulatus canaliculatus). Folia inferiora lanceolata subacuta, superiora *ovata subamplectentia*, $1\frac{1}{2}$ pollices longa, 1 pollicem lata, coriacea, apicibus inæqualiter bilobis, vaginis pollicem longis, oribus integris striolatis (siccis) atro-purpureis. Racemi brevissimi, $\frac{1}{8}$ poll. longi. Bractea ovata acuta, parva. Flos carnosus, ovario in pedicello $\frac{1}{2}$ poll. longo. Sepala *ovata acuta*, $\frac{3}{8}$ poll. longa, $\frac{1}{4}$ poll. lata. Mentum *rectum conicum, ovarium superans.* Petala angustiora. Labellum pollicem longum; *lobi laterales oblongi excurvi obtusissimi*, apicibus rotundatis; *lobus medius obcuneatus, apice rotundato emarginato*, $\frac{3}{8}$ poll. longus, ferme $\frac{1}{2}$ poll. latus. Columna breviuscula, clinandrio profundo. Stelidiis ovatis acutis, majusculis.

Beutang Lupar, Sarawak (*Bishop Hose*).

The largest and stoutest of this section, remarkable not only for its large size but also for its large ovate leaves.

D. UNIFLORUM, *Griff. Notul.* iii. p. 305. Matang, growing on a shrub at 2000 feet alt. (*Haviland*).

D. BIFARIUM, *Lindl. in Wall. Cat.* n. 2002. Sarawak (*Haviland*).

D. HOSEI, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iii. (1893) p. 363. Kuching, Sarawak (*Bishop Hose* !) (*Haviland* !).

The leaves of the Bornean form are a little narrower than that of the Pahang one.

D. DISTACHYON, *Lindl.*, D. LYCOPODIOIDES, *Lindl.*, and D. TMESIPTERIS, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 13, belong apparently to this section. The two latter were collected at Sarawak by Lobb, but apparently not recently.

D. (§ PEDILONUM) SECUNDUM, *Lindl. in Wall. Cat.* n. 1996, *et Bot. Reg.* t. 1291. Sarawak (*Haviland*).

Var. BURSIGERUM (D. bursigerum, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 16). Sarawak (*Bishop Hose* ! *V. v.*).

This variety is only a poor and weak form of the common plant.

D. CUMULATUM, *Lindl. in Gard. Chron.* (1855) p. 756. Kuching, Sarawak. Sepals and petals white, lip with red longitudinal lines (*Haviland* !).

DENDROBIUM SANGUINOLENTUM, *Lindl. Bot. Reg.* (1842), *Misc.* p. 62. Pontianak, Suitang! *V. v.*

D. PICTUM, *Lindl. in Gard. Chron.* (1862) p. 548; D. RADIANS, *Reichb. f.*; D. LILACINUM, *Reichb. f.*; D. LUCENS, *Reichb. f. Xenia Orch.* ii. pp. 130–132, belonging to this section, were introduced into cultivation from Borneo.

D. (§ PEDILONUM) ANTHRENE, sp. nov.

Caules *longi*, ultra pedales, *graciles debiles,* internodiis 1½–1 pollicem longis, basibus angustatis, superne incrassatis striatis, ¼ poll. crassis. Flores 1–2 *in racemo brevissimo* versus apicem caulis nudi, magni ad 3-pollicares, pedicellis pollicaribus. Bracteæ ⅛ poll. longæ, lanceolatæ. Sepala *ovata obtusa,* ⅜ poll. longa, ½ poll. lata, pallide rosea, basi flavescenti. Mentum *grande,* 1¼ *poll.* longum, ½ poll. crassum, arcuatum, versus apicem angustatum, apice dilatato obtuso. Petala *ovata obtusa, sepalis latiora.* Labellum *subspathulatum panduratum,* obtusum, *lobis lateralibus vix distinctis* obtusis, 1½ poll. longum, pallide flavum, striis rubris, *callo parvo* ad basin *rotundato.* Columna longa, superne dilatata, roseo-flavescens. Stelidia lata, apicibus dentiformibus antheram superantibus. Anthera ovata rostrata, rostro retuso. Filamentum longum. Stigma parvum, rotundatum.

Sarawak (*Bishop Hose. V. v.*).

I have never seen the foliage of this very big-flowered *Pedilonum.* The flowers are probably the largest in the section: they resemble at a little distance a large-bodied hymenopterous insect, the mentum representing the body.

BULBOPHYLLUM (§ OXYSEPALA) CLANDESTINUM, *Lindl. Bot. Reg.* (1841), *Misc.* p. 77. Sarawak!

B. (§ SARCOPODIUM) MACRANTHUM, *Lindl. Bot. Reg.* (1844) t. 13. Common. The form with small flowers seems more abundant than the large-flowered one of the Peninsula. Laudak (*Dare*).

B. RETICULATUM, *Batem. ex Hook. f. Bot. Mag.* t. 5605. Braang (*Haviland*).

B. INSIGNE, sp. nov.

Pseudobulbi vix remoti, oblongi, virides, corrugati, 1–1½ poll. longi. Folium oblongum oblanceolatum subacutum coriaceum,

basi angustatum, 8 pollices longum, 1½ poll. latum, viride (juvene sanguineo-maculatum). Scapus pseudobulbo approximatus brevis, 1½ poll. longus, vaginis 2 brevibus lanceolatis acutis pallidis sanguineo-maculatis. Bractea pollicaris, subsimilis. Pedicellus cum ovario carinato 2-pollicaris. Sepalum *posticum ovatum acutum grande,* 1½ poll. longum, ½ poll. latum, aurantiaco-kermesinum marmoratum, lateralia deflexa parallela majora obtusa ochrea. Petala *recurva, lineari-lanceolata acuminata,* 1½ poll. longa, ¼ poll. lata, aurantiaca, margine et fascia mediana kermesinis. Labellum breve, carnosum, crassum, *stipitatum,* medio canaliculatum, *lateribus ad basin pubescentibus, apice abrupte incurvo, pustulato,* atro-purpureum. Columna brevis, crassa, flava. Stelidiis *bidentatis, dente superiore brevi erecto, inferiore longiore porrecto.* Pes columnæ longus angustus.

Borneo, loc. incert. (*Durnford! V. v.*).

The most beautiful of all the *Sarcopodiums* I have seen, with large orange sepals and petals marked with crimson, and a dark purple lip.

BULBOPHYLLUM MANDIBULARE, *Reichb. f. in Gard. Chron.* (1882), I. 366, was collected in Borneo by Burbidge.

B. (§ SARCOPODIUM) RETICOSUM, sp. nov.

Pseudobulbi subglobosi, approximati, 1 poll. longi, ½ poll. lati, fibrillis pluribus ad basin. Folium lanceolatum coriaceum petiolatum, 4 pollices longum, 1¼ poll. latum, læte viride. Scapus brevissimus vix ¼ poll. longus, bracteis ovatis lanceolatis acutis, tectus. Flos *maximus,* pedicello valido ochreo ferme 3 pollices longo. Sepalum *posticum lanceolatum acuminatum,* 2 pollices longum, ½ poll. latum, pallidum ochreo reticulatum; *lateralia* carnosiora explanata, *falcata acuminata* pollicaria, ochracea, fasciis medianis violaceo-purpureis. Petala recurva lineari-lanceolata acuta, 1½ poll. longa, albescentia, nervis ochraceis. Labellum ½ poll. longum, *stipitatum* carnosum, basi profunde excavatum, *lateribus cornutis, pubescens,* purpurascens, apice decurvo, *alis erectis obtuse falcatis,* albis, alis purpurascentibus ad basin. Columna lata, pede longo ultra semipollicaris, stipite longiusculo aurantiaco, marginibus et lineâ medianâ rufis. Stelidia *vix distincta, obtusa, aliformia.* Anthera triangulari-conica, parva. Stigma transversim oblongum.

Borneo (*Durnford*). Fl. in Hort. Bot. Singap., June 1894.

BULBOPHYLLUM (§ SARCOPODIUM) SUBUMBELLATUM, sp. nov.

Rhizoma longe repens, gracile. Pseudobulbi approximati vel longe ad 5 pollices dissiti, cylindrici, 2 pollices longi, $\frac{3}{8}$ poll. crassi. Folium lanceolatum acutum petiolatum, 5–6 pollices longum, $1\frac{1}{4}$ poll. latum (in sicco multistriatum). Scapus juxta pseudobulbum crassiusculum, 4-pollicaris, vaginis 4–5 ovatis cuspidatis dissitis, porte summa $\frac{1}{4}$-pollicari. Flores 2–3, *pedicellati, subumbellati, majusculi.* Bracteæ ovatæ cuspidatæ, $\frac{1}{4}$-pollicares. Pedicelli cum ovariis $\frac{3}{4}$-pollicares, tenues. Sepalum posticum ovatum acutum, ferme pollicem longum, $\frac{3}{8}$ poll. latum; lateralia subæqualia torta, marginibus appressis. Petala sepalis *multo breviora late ovata,* $\frac{3}{8}$ poll. longa, $\frac{1}{4}$ poll. lata. Labellum *stipitatum, linguiforme,* $\frac{1}{2}$ poll. longum, curvum acutum. Columna brevis. Stelidia *brevissima vix distincta,* pede longo gracili curvo. Capsula immatura elongata, oblonga, $1\frac{1}{2}$-pollicaris.

Prope Kuching, Sarawak (*Haviland*); also ad Kampong, Simpai; Hulu Batu Paha et Sungei Malitil in Johore in peninsula Malaiensi australi (*Lake & Kelsall*).

The flowers of this plant are described as greenish yellow, thickly striped and mottled with red, by Dr. Haviland, and by Lieut. Kelsall as "ground yellowish, crimson spots."

It is evidently a true *Sarcopodium,* with, however, usually at least more than one flower in a raceme, so short that it appears to be an umbel. The Bornean specimens are shorter and more compact than those of Lahore. The habit of the latter is somewhat like that of *B. Reinwardtii*, Reichb. f., but smaller. The arms of the column are represented merely by angles.

B. MONTENSE, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 234. Kinabalu, epiphytic, 11,000 ped. alt.

B. CATENARIUM, *Ridl. l. c.* p. 235. Kinabalu ad 6500 ped. alt. (*Haviland*).

B. (§ RACEMOSÆ) BECCARII, *Reichb. f. in Gard. Chron.* (1879) I. p. 41. Pontianak (*native collector*).

B. (§ RACEMOSÆ APODÆ) APODUM, *Hook. f. Fl. Brit. Ind.* v. p. 766. Kuching, Sarawak (*Haviland*).

This and the following four species belong to a well-marked series in which the leaves appear to arise from a stout rhizome directly, without any stem or pseudobulb. The raceme is erect, with a number, sometimes very large, of small or very small flowers, yellow, with the lip usually darker.

BULBOPHYLLUM CORIACEUM, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 235. Kinabalu, ad 10,500 ped. alt.

B. (§ RACEMOSÆ) ELATIUS, sp. nov.

Rhizoma ligneum, crassum, radicibus validis. Pseudobulbi *globosi, ½ poll. longi*, crassi. Folium magnum coriaceum, petiolo 5-pollicari, crasso; lamina ovato-oblonga obtusissima, plurimi-nervia, 8 pollices longa, 4 pollices lata. Scapi *validi*, 1½-pedales, basibus longe nudis, vaginis dissitis longis exceptis. Racemus pubescens, plurimiflorus, erectus. Flores *perparvi*, albescentes. Bracteæ lineares acuminatæ, ¼ poll. longæ, persistentes. Pedicelli bracteis paullisper longiores, pubescentes. Sepala *ovata* subobtusa alba, lateralia basi connata. Petala sepalis *multo minora* columnam vix superantia, alba. Labellum tenue, *lanceolatum*, apice decurvo unguiculato, bruneum. Columna oblonga. Stelidia *elongata, decurva, acuminata.*

Ulu Tawarar, 2000 ft. (*Haviland*, 1371); Sarawak (*Bishop Hose*, Oct. 1893); Sumatra, Ayer Mancior, Padang (*Beccari* no. 559 *in Herb. Brit. Mus.*).

This species is closely allied to *B. odoratissimum*, Lindl., but differs in the much shorter-sepalled white flowers.

B. (§ RACEMOSÆ) PUBERULUM, sp. nov.

Rhizoma haud crassum, radicibus copiosis. Folia haud longe dissita ovata vel ovata lanceolata, petiolata, subacuta, striolata, 2–4 pollices longa, 1 pollicem lata, petiolo 1–2-pollicari. Racemi *debiles, foliis breviores*, 2-pollicares, foliis approximati; vaginæ ad basin lanceolatæ. Flores *plures*, dissiti. Bracteæ lanceolatæ acuminatæ, $\frac{1}{16}$-pollicares, pedicellos æquantes. Sepala *lanceolata longe acuminata*, ¼ poll. longa; lateralia basi latiora, mentum scrotiforme formantia. Petala *lanceolata, sepali postici dimidio æqualia*, pubescentia. Labellum tenue, *basi latâ ovatâ, apice lanceolato obtuso pubescente.* Columna brevis pede longo tenui nec apice libero. Stelidia *oblonga bidentata*, dentibus subæqualibus.

Sarawak, "Limestone Rocks" (*Haviland*!).

This in many respects resembles *B. leptosepalum*, Hook. f., but differs in the shape of the lip, which has a broad base, the sides of which are curved up to form a cup, and an abruptly narrow apex, which is pubescent. The petals are also pubescent. The stelidia are two-toothed. The flowers appear to have been bright yellow.

Bulbophyllum montigenum, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 235.

Kinabalu, ad 6000 ped. alt.

B. breviflorum, *Ridl. l. c.* p. 236.

Kinabalu, ad 6000 ped. alt.

B. § Intervallatæ, sect. nov.

Rhizoma sæpe crassum, pseudobulbis conicis majusculis vel subnullis. Folia coriacea, sæpe magna. Scapus rigidus elatus, majore parte nudus, apice racemoso incrassato, bracteis approximatis appressis ovatis. Racemus multi sæpe plurimiflorus, flores majusculi singulatim intervallis longis expansi. Sepala lanceolata acuminata vel caudata. Petala perparva. Labellum majusculum. Columnæ stelidia brevia.

Species adhuc notæ tres, in arboribus sylvarum Malayensium, crescentes.

This is a very distinct section of *Bulbophyllum*, remarkable for possessing a tall stiff scape ending in a many-flowered raceme, the flowers of which are expanded one by one at long intervals, the rachis slowly elongating as they are expanded, so that, though in one species as many as eighty flowers are eventually borne on the raceme, no two are open at one time, and many weeks elapse between the opening of the first and last flowers. A similar method of flowering occurs in many of the *Sarcochili*, as in the section *Cucullati* (e. g. *S. Arachnites*, Reichb. f., and *S. notabilis*, Hook. f.), and also in *Oncidium Papilio*, Lindl. The flowers are rather fugacious, lasting for little more than a day. In two of the species they are widely expanded when open, the other is (usually, at least) cleistogamous and does not open at all. The lip is channelled, with the channel filled with nectar; it does not move freely on the foot of the column as is usual in the rest of the genus, but is quite stiff and porrect.

Though two of the species are not, so far as I know, natives of Borneo, I have thought it best to describe all together.

B. tardeflorens, sp. nov.

Rhizoma crassum lignosum, radicibus longis tectum, *pseudobulbis subnullis*. Folium *ovatum*, basi attenuatum, apice obtusum crassum coriaceum atro-viride, 9 pollices longum, 3 pollices latum. Scapus folio approximatus, gracilis, teres rigidus erectus ultrapedalis. Racemus crassior cylindricus, bracteæ amplectentes ovatæ. Flores plurimi, *magni*. Sepalum *posticum lanceolatum*

longe cuspidatum erectum, 2 poll. longum; lateralia subsimilia deflexa, aurantiaca, striis obscurioribus. Petala brevissima, $\frac{1}{4}$-pollicaria, oblonga lanceolata, columnæ vix æqualia. Labellum lanceolatum acuminatum, $1\frac{1}{2}$ poll. longum, ferme $\frac{1}{2}$ poll. ad basin latum, basi emarginatum canaliculatum, carinis duabus elevatis in lateribus canaliculi, pallide aurantiacum minute kermesino-punctatum. Columna crassa brevis, pallide aurantiaca, stelidiis rotundatis brevibus; margine clinandrii vix elevato. Anthera hemisphærica, margine antico sinuato, pallide flava. Rostellum breve, vix productum. Stigma subtriangulare, profundum. Pes columnæ elongatus, apice libero.

Borneo. (Cult. in Hort. Bot. Singapore.)

This species differs from *Bulbophyllum Stella* in the absence of pseudobulbs, broader leaves, larger flower with long cuspidate sepals, and colour.

[BULBOPHYLLUM STELLA, sp. nov.

Pseudobulbi approximati *ovoidei* olivacei corrugati, $\frac{3}{4}$-pollicares, juniores vaginâ singulâ magnâ tenui papyraceâ striolatâ tecti; radicibus copiosis. Folia 6 pollices longa, $1\frac{1}{2}$ poll. lata, lanceolata subobtusa, basi angustata, crassa. Scapi elongati, rigidi, $1\frac{1}{2}$-pedales, majore parte, vaginis paucis exceptis, nudi. Racemus circiter 80-florus, teres incrassatus, rhachide pulvinis rotundatis tectâ. Bracteæ ovatæ, $\frac{1}{8}$ poll. longæ. Ovarium cum pedicello $\frac{1}{2}$-pollicare. Flos speciosus, explanatus. Sepala *lanceolata caudata*, basi latiora, $1\frac{1}{4}$ poll. longa, $\frac{1}{8}$ poll. lata, flava rubro-vittata. Petala brevissima oblonga obtusa ovata, $\frac{1}{8}$ poll. longa, flava, vittis rubris. Labellum oblongum lanceolatum acuminatum, $1\frac{1}{2}$-pollicare, roseum, basi obscuriore, carinis duabus e basi versus apicem attenuatis, inter quas canalicula. Columna viridis, brevis, parte superiore pedi æquali. Stelidia brevia. Anthera parva depressa, in clinandrio immersa. Stigma majusculum.

Singapore: Kranji. In dense forest on the trunks of trees low down. There is a figure of this plant also among Scortechini's drawings.]

[B. CLEISTOGAMUM, sp. nov.

Rhizoma pseudobulbis pluribus approximatis tectum; pseudobulbi *conici* sulcati, $\frac{3}{4}$ pollices longi, læte virentes. Folium oblongum petiolatum subacutum, canaliculâ distinctâ, carinâ dorsali paullo elevatâ, 4–6 pollices longum, $\frac{3}{4}$–1 pollicem latum, petiolo profunde

canaliculato, $\frac{1}{2}$ poll. longo. Scapi plures rigiduli teretes, ad 12 pollices longi, virides, bracteis siccis subacutis, $\frac{1}{2}$-pollicaribus arcte amplectentibus. Racemus breviusculus complanatus, bracteis ovatis acutis, mucronatis, $\frac{1}{4}$-pollicaribus amplectentibus. Flores mediocres *cleistogami*, sæpissime clausi, raro paullo expansi. Sepala *lanceolata acuminata* acuta, pallide straminea, $\frac{3}{4}$ poll. longa, lateralia basi dilatata intus rubescentia. Petala *minuta quadrata* subdenticulata, mucrone subulato longiusculo, viridia. Labellum *elongatum curvum acutum*, basi latâ, lobis duobus lateralibus parvis falcatis, carinis duabus approximatis a basi usque ad geniculum, basi kermesinum, apice stramineum. Columna brevis crassa viridis, margine clinandrii denticulato. Stelidia *subulata erecta*, pede kermesino haud producto. Anthera ovata. Rostellum *nullum*.

Riouw (Rhio) (*native collector. V. v.*).

This is a smaller plant than *Bulbophyllum Stella*, and differs, too, in the presence of distinct lateral lobes on the lip, subulate petals, colouring, &c. It appears to be always self-fertilized, and usually the flower never opens; but in one specimen the flower partially opened. From the absence of the rostellum it is easy for the pollen to find its way into the stigma.]

BULBOPHYLLUM (§ CAPITATÆ) CONCINNUM, *Hook. f. Ic. Pl.* t. 2538 A. Braang (*Haviland*!).

B. CAPITATUM, *Lindl. Gen. et Sp. Orch.* p. 56. Bungok (*Haviland*).

B. ALTISPEX, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 236. Kinabalu, ad 8000 ped. alt. (*Haviland*).

B. PEDICELLATUM, sp. nov. (Plate ~~XIV.~~)

Rhizoma tenue, radicibus multis, pseudobulbis oblongo-conicis approximatis pollicaribus. Folium ellipticum lanceolatum, 5 pollices longum, $\frac{3}{4}$ poll. latum, obtusum. Scapi *plures*, ad 3 poll. longi, graciles, bracteis 2–3 dissitis. Racemus *brevissimus, umbellam simulans*, $\frac{1}{8}$ poll. longus. Bracteæ lanceolatæ acutæ, breves, $\frac{1}{16}$–$\frac{1}{8}$ poll. longæ. Pedicelli filiformes, pollicares. Flores parvi, odori, ad 10. Sepala æqualia *lanceolata acuminata*, lateralia falcata, $\frac{1}{4}$ poll. longa. Petala lanceolata obtusa, dimidio sepali æqualia. Labellum *brevissimum, lineare*, angustum, carnosum, flexum sessile. Columna crassa, pede brevissimo. Stelidia dentiformia, brevissima.

Sarawak (*Haviland*). Etiam ad Punga in Siam a Curtis detecta!

A very curious little plant with the habit of *Cirrhopetalum*, but with unusually long pedicels, and the sepals of one of the section *Racemosæ*. The flowers are yellowish white and sweet-scented, and the plant is very floriferous. Except for the equality of the sepals this might well be referred to *Cirrhopetalum*, but the difference in size of the upper and lower sepals really constitutes the whole distinction between the two genera.

CIRRHOPETALUM GAMOSEPALUM, *Griff. Notul.* iii. p. 296. Sarawak (*Bishop Hose*!). Sandakan (*Pryer*!).

C. BRUNNESCENS, sp. nov.

Pseudobulbi conico-tetragoni, pollicares. Folium oblanceolatum obtusum, 6 pollices longum, $1\frac{1}{4}$ poll. latum. Scapus gracilis, ruber, 3-pollicaris. Flores ad 5, iis *C. Makoyani* æquales. Pedicelli et bracteæ parvæ, lanceolatæ acutæ, rubri. Sepalum posticum cymbiforme ovatum cuspidatum, purpureo-bruneum, margine purpureo-ciliato, $\frac{3}{16}$ poll. longum, *lateralia connata angusta linearia*, subacuta, $\frac{3}{4}$ poll. longa, $\frac{1}{16}$ poll. lata, pallide flavescentia, marginibus ad basin purpureo-bruneis. Petala rhomboidea cuspidata, margine ciliato, basi flavescentia purpureo-maculata, apice abrupte purpureo-brunea. Labellum parvum *linguiforme curvum*, purpureo-bruneum, apice subacuto aurantiaco. Columna pallide flava, purpureo-maculata. Stelidia brevissime linearia.

Borneo (loc. incert., cult. in hort. W. Nanson ad Singapore! *V. v.*).

This species is an ally of *C. Makoyanum*, Reichb. f., differing not only in colouring but in its flat broader lip. It flowered among other Bornean orchids, the exact locality of which was not known, in a private garden in Singapore.

C. MEDUSÆ, *Lindl. Bot. Reg.* (1842) t. 12. This species is common about Sarawak (*Haviland, &c.*).

C. VAGINATUM, *Lindl. in Wall. Cat.* n. 1979. Sarawak (*Haviland*).

C. CITRINUM, sp. nov.

Rhizoma lignosum longe repens, fibrillis vaginarum vetustarum tectum. Pseudobulbi vix pollicem longi, *conici*, rugosi, pollicem distantes. Folium obovatum obtusum carnosum, $1\frac{1}{2}$ poll. longum,

$\frac{3}{4}$ poll. latum, apice retuso. Pseudobulbi et folia sæpe purpurei vel atro-virides, margine purpureo. Scapus gracilis, folio brevior vel longior, filiformis. Flores parvi, *citrini, circiter* 10 in verticillo completo. Bracteæ lineares cymbiformes, acutæ, purpureæ (vel pallidæ), pedicellis ferme æquales. Sepalum *posticum ovatum acuminatum eciliatum, lateralia libera linearia* plana acuta. Petala ovata lanceolata acuminata acuta. Labellum carnosum curvum lanceolatum subacutum, carinis duabus latis. Columna crassa, alis latis distinctis. Anthera depressa, filamento triangulari. Stelidia brevissima, subacuta. Stigma grande, ellipticum.

Sarawak (*Haviland*), etc. Also in the Malay Peninsula at Singapore and Freshwater Island, and on Mt. Ophir on rocks.

A curious little species, usually very compact, with the leaves lying rather flat on the pseudobulbs. The scape varies very much in height, but is usually quite short. The flowers a pale yellow, sometimes nearly white. It is not at all rare, and is usually to be found on trees in rather dry spots.

Dendrochilum conopseum, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 236. Kinabalu, Mari-pari, 5500 ped. alt. (*Haviland*).

Eria obliqua, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 55. Kuching (*Haviland*).

E. bifalcis, *Lindl. l. c.* p. 56. Borneo (*Lobb*). Not seen.

E. major, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 237 in syn.

E. (§ Eriura) crucigera, sp. nov.

Caulis *elatus*. Folia remota $1\frac{1}{2}$ poll. dissita disticha linearia, inæqualiter acuminata, acumine uno longiore $\frac{3}{4}$ poll., 8 poll. longa, $\frac{3}{4}$ poll. lata; carina et costa una subtus prominula. Scapi *circiter* 4, graciles, nutantes, albo-lanuginosi, 10-pollicares. Bracteæ lanceolatæ reflexæ, circiter $\frac{1}{5}$ ovarii æquales. Ovarium cum pedicello $\frac{1}{4}$ poll. longum, albo-lanuginosum. Flores parvi, lanuginosi. Sepalum posticum oblongum obtusum; lateralia ovata oblonga, mento brevi obtuso. Petala linearia, glabra. Labellum tenue, disco lineari, lobis lateralibus oblongis loratis obtusis elongatis, medio unguiculato, ungue lobis lateralibus æquali; *lobis 2 linearibus oblongis obtusis* transversis, *inter eos callus*

crassus conicus obtusus tuberculosus erectus. Callus ad basin labelli conicus. Columna brevis, superne dilatata.

Trusan River (*Haviland*).

ERIA GRANDIS, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894 p. 237. Kinabalu, 10,500 ad 12,000 ped. alt.

E. ANGUSTIFOLIA, *Ridl. l. c.* Kinabalu, 6000 ped. alt. (*Haviland*).

E. (§ HYMENERIA) DENSA, sp. nov.

Caules (pseudobulbi) aggregati erecti crassi *cylindrici*, 8 poll. longi, *pollicem crassi*, vaginis pallide bruneis tecti. Folia 4 congesta ad apicem caulis, 11 pollices longa, 2 pollices lata, lanceolata lorata, tenuiter coriacea, subacuta, carinata. Racemi laterales patentes 9-pollicares, rhachide pubescente rubro tereti, *dense floriferi.* Bracteæ persistentes reflexæ tenues ovales, lineam longæ. Flores *copiosi* parvi, iis *E. floribundæ* similes, albi roseo tincti. Pedicelli cum ovariis $\frac{1}{4}$-pollicares, rubri. Sepalum posticum ovatum, lateralia ovata triangularia, ferme obtusa. Petala ovata, sepalo postico æqualia, angustiora, patula. Labellum breve angustum, basi quadratum; *lobi laterales falcati acuti*; *lobus medius spathulatus*, apice retuso lato valde obscure trilobo, lobis brevissimis subæqualibus, basi longus angustus. Columna crassa alba, pede longo. Clinandrium et margo stigmatis ruber. Stigma latum subreniforme, margine inferiore sinuato. Anthera plana atro-rubens, margine flavo. Rostellum majusculum, ovatum, kermesinum.

Sarawak (*Haviland*!) Perak, Larut hills! Hermitage hills. *V. v.*

This plant has long been cultivated in the Botanic Gardens, under the name of *Eria musæfolia*, but I cannot find this name published anywhere, nor is it at all an expressive name. It is closely allied to *E. floribunda*, Lindl., with which I suppose it has been confused in the 'Flora of British India;' but besides its much larger size, it differs in its denser raceme, and in the shape of the lip, in which the lateral lobes are arched from the base and falcate, and the lateral lobe has a much longer claw ending in a narrower spathulate portion, the edge of which is sinuate so as to be very obscurely trilobed. The stigma, too, is much narrower and longer, with a waved, not straight lower margin. The two plants, which flower regularly, produce blossoms

at different times of the year. *Eria densa* has the flowers nearly white in the lower part of the hills, but above 2000 feet alt. they are vinous purple.

ERIA (§ HYMENERIA) CEPIFOLIA, sp. nov.

Caules *plures* congesti, radicibus copiosis, 3 pollices alti, *basi teretes superne incrassati*, internodiis tribus lateraliter dilatatis striatis. Folia ex internodiis dilatatis exortis, *teretia acuta*, ad 6 pollices longa. Racemi *multiflori*, ad 6 pollices longi, lanuginosi. Flores parvi, albi, odori, reversi. Bracteæ lanceolatæ, $\frac{1}{16}$ poll. Pedicelli longiores, lanuginosi. Sepala *ovata, pubescentia*, lateralia, mentum crassum obtusum formantia. Petala lanceolata, angustiora. Labellum *trilobum, lobi laterales erecti dentiformes* acuti, *medius spathulato-cuneatus*, apice obscure mucronato; unguis basi depressus nectarium formans. Columna brevis crassa, stelidiis latis incurvis, pede anguste longo, violacea. Anthera oblonga depressa, violacea. Pollinia subæqualia, pyriformia.

Sarawak (*Bishop Hose*. *V. v.*).

A very remarkable plant, allied to *E. floribunda*, Lindl., with the stems narrow and slender at base, suddenly dilated for the uppermost three internodes, which are much enlarged laterally and vertically, and bear each a dark green terete leaf. In drying the fleshy internodes shrink, so that dried specimens do not give the exact appearance. The flowers resemble those of *E. floribunda*, Lindl. I have twice received this alive from Sarawak. There is a figure among Scortechini's drawings of Malay orchids which I suspect is meant for this, but I have not myself seen it in the peninsula.

E. LEPTOCARPA, *Hook. f. Fl. Brit. Ind.* v. p. 805. Sarawak (*Haviland*).

E. (§ NUTANTES) LONGE-REPENS, sp. nov.

Rhizoma *longe repens*, $\frac{1}{4}$ poll. crassum, radicibus paucis tenuibus. Peudobulbi *teretes* remoti, 4-pollicares, vaginis brevibus $\frac{3}{4}$ poll. longi tecti. Folia terminalia 3–4 lanceolata vel ovato-lanceolata acuta vel acuminata petiolata, laminâ 6 pollices longâ, 2 pollices latâ, petiolo $\frac{1}{2}$-pollicari. Racemus lateralis infra folia, brevis, $\frac{1}{2}$ poll. longus, 2–3-florus. Bracteæ oblongæ, carneæ, $\frac{1}{2}$-pollicares. Flores iis *E. nutantis* æquales. Sepala *ovata lanceolata* acuta, lateralia majora, mente oblongo, sepalis

æquali, roseo-flava, lineâ medianâ extus obscuriore. Petala multo minora lanceolata acuta, flavescentia. Labellum *oblongum truncatum integrum*, album, fasciâ medianâ paullo elevatâ, striis rubris. Columna clavata, stelidiis incurvis obtusis; alba, macula ad basin kermesina. Stigma grande, ovoideum. Anthera parva ovata acuta. Capsula angusta, longa, 2-pollicaris.

Sarawak (*Haviland!*). Etiam Singapore in arboribus ad Kranji et Sungei Morai. *V. v.!*

This is a very distinct plant of the *Eria nutans* section, remarkable for the long creeping rhizome which climbs on small trees low down in dense jungle near the mangrove swamps, very much after the manner of *Claderia*. The pseudobulbs, which are no thicker than the rhizome, are six or seven inches apart, as thick at one end as the other, and terminated, as in *E. nutans*, by a few leaves. The flowers are much after the style of those of *E. nutans*, and the large coloured bracts are similar, but the raceme appears below the leaves. The description is taken from Singapore specimens, but the Bornean plant is identical.

ERIA (§ NUTANTES) NEGLECTA, sp. nov.

Rhizoma *diu repens, multiramosum*, gracile, vaginis bruneis tectum, cæspitem in ramis arborum formans. Caules erecti, basibus teretibus *superne incrassati* et compressi, $\frac{1}{4}$ poll. crassi (quo crassissimi), 5 pollices alti. Folia 1–2 ad apices caulinum lanceolata flaccida acuta, læte flava, $3\frac{1}{2}$ pollices longa, $\frac{3}{4}$ poll. lata; carina indistincta. Flos singulus subterminalis, pedicello brevi, bracteam latam bruneam $\frac{1}{2}$ poll. longam vix superanti, suberectus, quam flos *E. nutantis* minor. Sepala lanceolata, lateralia ferme ovato-lanceolata subacuta, $\frac{1}{4}$ poll. longa. Petala breviora lanceolata, cum sepalis revoluta, alba roseo tincta. Labellum sepalis longius, basi anguste oblongum, *lobis lateralibus* roseis *falcatis acutis* erectis, *lobo medio* flavo *oblongo-quadrato*, apice retuso. Carinis 2 roseis, lateralibus brevibus e basi, unâque mediâ minus elevatâ ad apicem lobelli terminatâ et hic incrassatâ et sinuatâ. Columna paullo arcuata rosea, dorso obscuriore, lateribus rectis, papillâ quadratâ albâ ad apice pedis. Pollinia 8, pallide flava.

Sarawak (*Haviland*). Also Singapore; common on trees in the mangrove swamps at Kranji and elsewhere. Penang (*Curtis*).

This is a close ally of *E. nutans*, Lindl., and dried specimens

may easily be mistaken for it. It is, however, much smaller, the stems very numerous, forming a large turf on the branches of the trees. The pedicel is erect, not recurved and nodding, the flower smaller and never white, the lateral lobes of the lip much narrower, and the mid-lobe of a different shape.

ERIA (§ BAMBUSÆFOLIA) ELONGATA, sp. nov.

Caules validi, teretes, 4-*pedales*. Folia *plura linearia acuminata* inæqualiter biloba, 7 pollices longa, ½ poll. lata, vaginis 1½-pollicaribus oribus integris. Racemi *laterales brevissimi*, ⅛-pollicares. *Bracteæ* 4 *late lineares* acutæ, ½-poll. longæ, flavæ. Flores singuli fugaces, ovariis cum pedicellis ½-pollicaribus flavescentibus. Sepalum *posticum lanceolatum acutum lateralia* basi *late lanceolata falcata*, ½ poll. longa. Petala linearia acuta falcata, omnia alba, extus bruneo-maculata. Labellum *obovatum*, sepalis brevius, album, lobis lateralibus falcatis acutis, *medio breviore lanceolato* marginibus incurvis sinuosis, flavo, quam lateralia breviore, disco inter lobos laterales elevato. Columna longiuscula. Anthera conica, breviter rostrata. Stelidia lata, inflexa. Rostellum planum, brevissime rostratum. Pollinia 8, quorum 4 parva ovoidea, 4 oblonga elliptica.

Sarawak (*Bishop Hose*). *V. v.*

A tall stiff plant with the habit of *Dendrobium gemellum*, Lindl., but the flowers and bracts are those of the *Nutantes* section of *Hymeneria*.

E. (§ TRICHOTOSIA) FEROX, *Blume, Mus. Bot. Lugd.-Bat.* ii. p. 184. Sintang (*Teysmann* 17339 *in Herb. Bogor.* !). Kinabalu, 6000 feet alt. (*Haviland*).

E. TUBEROSA, *Hook. f. Fl. Brit. Ind.* v. p. 807. Sarawak (*Haviland* !). A form with the lip most obscurely lobed, mid-lobe oblong.

E. VELUTINA, *Lodd. ex Lindl. Bot. Reg.* (1840), *Misc.* p. 86. Kuching, Sarawak (*Haviland* !).

E. VESTITA, *Lindl. Bot. Reg.* (1844), *Misc.* p. 76. Saribas River (*Haviland* !).

E. PAUCIFLORA, *Blume*, and E. CANALICULATA, *Blume, Mus. Bot. Lugd.-Bat.* ii. pp. 183-184, collected at Martapoera (S. Borneo); and E. RUBIGINOSA, *Blume, l. c.* p. 184, from Sakoembang, belong to this section.

ERIA (§ DENDROLIRION) PULCHELLA, *Lindl. in Wall. Cat.* n. 7407. Braang, Sarawak (*Haviland* !).

E. PANNEA, *Lindl. Bot. Reg.* (1842), *Misc.* p. 64. Sarawak (*Bishop Hose*).

E. LEIOPHYLLA, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 57. Kuching, Sarawak (*Haviland*).

E. ORNATA, *Lindl. Gen. et Sp. Orch.* p. 66. Sarawak; Blitoeng, Sintang (*Teysmann* 17276, *Herb. Bogor.* !).

E. STELLATA, *Lindl. in Bot. Reg.* t. 904. Braang (*Haviland* !). Evidently common in Borneo, as it is often brought in by native collectors.

E. STRIOLATA, *Reichb. f. in Illustr. Hortic.* (1888) p. 35, t. 48. Pontianak (*Pryer*).

CLADERIA VIRIDIFLORA, *Hook. f. Fl. Brit. Ind.* v. p. 810. Sarawak (*Haviland*).

PHREATIA MYOSURUS, *Lindl. in Journ. Linn. Soc.* (*Bot.*) iii. (1859) p. 61. Braang (*Haviland*).

P. MINUTIFLORA, *Lindl. l. c.* p. 62, was originally described from Borneo specimens collected by Lobb.

SPATHOGLOTTIS PLICATA, *Blume, Bijdr.* p. 401. Sarawak (*Haviland*).

S. AUREA, *Lindl. in Journ. Hort. Soc.* v. (1850) p. 34. Kinabalu, Kinataki at 4000 ped. alt. (*Haviland* !).

ACANTHOPHIPPIUM JAVANICUM, *Blume, Bijdr.* p. 354. Trusan River (*Haviland*).

COLLABIUM SIMPLEX, *Reichb. f. in Gard. Chron.* (1881) I. p. 462, was obtained in " Borneo " by Burbidge.

NEPHELAPHYLLUM TENUIFLORUM, *Blume, Bijdr.* p. 373. Matang (*Haviland*).

N. LATILABRE, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 238.

TAINIA PLICATA, *mihi.*—Mitopetalum plicatum, *Blume, Mus. Bot. Lugd.-Bat.* ii. p. 185. " Corolla mottled with pink," Trusan River (*Haviland*).

PACHYSTOMA PANTANUM, *Miq. Fl. Ind. Bat.* iii. p. 675; Pachychilus pantanus, *Blume, Mus. Bot. Lugd.-Bat.* ii. p. 173. "Padang Pantan, Borneo" (*Korthals* fide *Blume*).

AGROSTOPHYLLUM MAJUS, *Hook. f. Fl. Brit. Ind.* v. p. 824. Sarawak (*Bishop Hose*).

A. SACCATUM, sp. nov.

Caules ultra 2 pedes alti, validi, compressi. Folia linearia, lata, subacuta, 6 pollices longa, pollicem lata, vaginis $1\frac{1}{8}$ poll. latis. Capitula magna, $1\frac{1}{4}$ poll. crassa, bracteis floribus æqualibus, $\frac{3}{8}$-pollicaribus, exterioribus mox in fibrillos resolutis. Flores iis *A. javanicæ* æquales. Sepala ovata carinata cuspidata. Petala lanceolata angustiora et tenuiora. Labellum sepalis æquilongum, *hypochilo saccato,* lobis lateralibus triangularibus erectis, *partitione transversali conjunctis,* epichilio ovali acuto, *mammillis duabus carnosis paullo elevatis.* Columna sigmoidea, sepalo postico subæqualis, apice dilatato, stelidiis rotundatis. Capsula fusiformis rostrata, ferme $\frac{1}{2}$-pollicaris.

Sarawak (*Haviland*).

Allied to *A. javanicum,* Blume, and *A. majus,* Hook. f., but differing from both in the hypochil being completely separated from the epichil by a transverse wall connecting the two lateral lobes. There is a pair of raised lumps on the ovate epichil which correspond to the calli present in *A. majus,* Hook. f. Like some other species the flowers are self-fertilized, the pollen by growth passing into the stigma over the edge of the rostellum; but apparently the fruit does not always mature. The bracts, especially the outer ones, have a tendency to split up into fibrils, giving the head a hispid appearance.

A. KHASIYANUM, *Griff. in Calc. Journ. Nat. Hist.* iv. (1844) p. 376, t. 19; Eria planicaulis, *Wall.* ! Borneo (*Teysmann in Herb. Bogor.* !).

CŒLOGYNE CUMINGII, *Lindl. Bot. Reg.* (1840), *Misc.* p. 76. Sandakan (*Pryer* !).

C. SPECIOSA, *Lindl. Gen. et Sp. Orch.* p. 39. Sarawak (*H. Everett* !).

C. PANDURATA, *Lindl. in Gard. Chron.* (1853) p. 791. Pontianak! Sintang! (*native collectors*); Matang, Sarawak (*Haviland* !).

Cœlogyne asperata, *Lindl. in Journ. Hort. Soc.* iv. (1849) p. 221. Pontianak! Sintang (*natives*); Braang! Kuching, Sarawak (*Haviland*!).

C. Foerstermanni, *Reichb. f. in Gard. Chron.* (1886) ii. p. 262. Braang, on a Durian tree (*Haviland*).

C. papillosa, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 238. Kinabalu (*Haviland*).

C. bilamellata, *Lindl. Fol. Orchid., Cœlog.* p. 14. Top of Santubong; Matang, 3000 feet alt. (*Haviland*). I suppose this to be Lindley's plant described from Cuming's "Philippine" plants. He does not, however, mention the conspicuous long petiole of the leaves, merely saying "foliis oblongis." The colouring is described by Dr. Haviland as "Lip white, with a brown spot in the middle."

C. tenuiflora, sp. nov.

Pseudobulbi *cylindrici*, 1½ pollices longi. Folia crassa elliptica lanceolata acuta petiolata; lamina 6 pollices longa, 1½ poll. lata. Scapus *e pseudobulbo immaturo* vaginis herbaceis tecto, gracilis, 3–4-pollicaris. Flores *parvi* dissiti, bracteis caducis (non visis), pedicellis gracilibus, ½-pollicaribus, ovariis ¼-pollicaribus. Sepala ovata lanceolata carinata, ½ pollicis longa. Petala linearia. Labellum tenue, basi anguste, lobis lateralibus anguste triangularibus breviusculis, *laminis duabus cum lineâ medianâ elevatâ in disco, lobo medio orbiculari* ¼ pollicis lato, *apice emarginato.* Columna brevis, alis latissimis, margine clinandrii denticulato. Anthera plana. Rostellum grande rostratum decurvum, margine stigmatis inferiore incrassato.

Trusan River (*Haviland*).

This small-flowered species belongs to the section with the flowers from an undeveloped pseudobulb. It seems to be allied to *C. sulphurea*, Reichb. f.

Pholidota imbricata, *Lindl. in Hook. Exot. Fl.* ii. t. 138. Braang; Sarawak (*Haviland*).

P. clypeata, *Lindl. in Journ. Hort. Soc.* v. (1850) p. 37. Borneo. It appears from description to be a variety of *P. imbricata*, and is probably intended for the above-mentioned plant, which is rather a short-racemed form.

PHOLIDOTA CADUCA, sp. nov.

Rhizoma crassum, vaginis magnis tectum. Pseudobulbi *dissiti elongati cylindrici*, 2 pollices longi, ½ poll. lati. Folia bina lanceolata cuspidata longe petiolata coriacea, laminâ 3–4 pollices longâ, pollicem latâ, petiolo 3-pollicari. Scapus ex apice pseudobulbi validus erectus, apice nutanti, 8-pollicaris, basi longe nudus, racemo flexuoso, *bracteis vacuis* 4 *ad basin* siccis striatis. Flores majusculi, bracteis lanceolatis siccis caducis. Sepala ecarinata ovata subacuta, $\frac{3}{8}$ poll. longa, $\frac{1}{4}$ poll. lata. Petala linearia, oblonga obtusa. Labellum *hypochilio saccato, epichilio plano oblongo-quadrato, apice bilobo,* lobis oblongis obtusis, marginibus lateralibus erosis, nervis in disco duobus elevatis, juxta hypochilium, callis triangularibus erectis terminatis. Columna basi anguste semiteres, alis magnis oblongis. Anthera pyriformia elongata rostrata. Rostellum longiusculum suberectum. Stigma protrusum.

Sarawak (*Haviland*).

A very curious plant with the pseudobulbs of the *Imbricatæ* section, though narrower and more distant, but distinct in possessing the persistent empty bracts at the base of the raceme, like those of a *Cœlogyne* of the *Proliferæ* section, while the floral bracts are very caducous. The plant might indeed be referred to *Cœlogyne* were it not for the lip, which is that of a true *Pholidota*, having a saccate base ending in a flat portion bilobed at the apex and erose at the sides, with two flat triangular calli at the entrance to the saccate hypochil. The column has large wings narrowed gradually to the base.

CALANTHE OVALIFOLIA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 239. Kinabalu, Penokok, 3000 ped. alt. (*Haviland*).

C. PARVIFLORA, *Lindl. in Paxt. Flow. Gard.* iii. (1852–53) p. 37, sub t. 61. Kinabalu, 7000 ped. alt. (*Haviland*).

ARUNDINA SPECIOSA, *Blume, Bijdr.* p. 401, t. 73; A. densa, *Lindl. Bot. Reg.* (1842), *Misc.* p. 25, t. 38; A. densiflora, *Hook. f. Fl. Brit. Ind.* v. p. 857, sphalm.; A. bambusifolia, *Lindl. in Wall. Cat.* n. 3751, *id. Gen. et Sp. Orch.* p. 125.

Sarawak (*Haviland*).

I have examined a number of specimens of the Himalayan, Javan, Malayan, and Bornean forms of this plant, and have seen it abundant in a wild state in various parts of the Malay Peninsula, besides keeping considerable quantities under cultiva-

tion for some years, and am quite unable to draw any distinction between the different forms of even varietal value. The Indian plant appears to be a little stouter and taller than the more compact form known as *Arundina densa*, Lindl., from the Malay Peninsula, but the plant varies in colouring and habit quite as much in the same locality.

It is abundant in rocky streams in the mountain-districts throughout the Malay Peninsula, but the locality "Singapore," given in the 'Flora of British India,' must be, I think, an error, as there is no likely locality for this plant here nor has it been met with of late years.

ARUNDINA PHILIPPI, *Reichb. f. in Linnæa*, xxv. (1852) p. 227; *Walp. Ann.* vi. p. 457. Borneo (*native collectors*). *V. v.*

This species occurs in Java also, where I have seen a white form, and in Hongkong. It is remarkable that Blume should have overlooked this plant, which is so conspicuous, in a locality where he collected many plants, viz., at Tjiboddas near Mt. Gedeh. It is quite distinct from *A. speciosa*, Blume, in its smaller flowers with yellow on the disc, and I have seen no intermediate forms.

DILOCHIA WALLICHII, *Lindl. in Wall. Cat.* n. 1952; *id. Gen. et Sp. Orch.* p. 38; Arundina Wallichii, *Reichb. f. Xenia Orch.* ii. p. 13. Dusun River (*Korthals* fide *Blume*); Sarawak (*Haviland*!).

I see no reason for reducing this genus to *Arundina*, from which it is so absolutely different in habit.

VANDEÆ.

EULOPHIA SQUALIDA, *Lindl. Bot. Reg.* (1841), *Misc.* p. 77. Sarawak (*Haviland*).

E. BORNEENSIS, sp. nov.

Rhizoma breve. Caules *vix bulbosi*. Folia 2, *linearia longe acuminata* petiolata, laminâ ultrapedali $\frac{3}{4}$ poll. latâ, petiolo 6-pollicari. Scapus $1\frac{1}{2}$-pedalis validulus, basi longe nudus, vaginis paucis dissitis exceptis, superne laxe racemosus. Flores flavi, remoti, iis *E. squalidæ*, Lindl., æquales. Bracteæ lanceolatæ acuminatæ acutæ, $\frac{3}{8}$-pollicares. Pedicelli graciles, $\frac{1}{4}$-pollicares, ovaria $\frac{1}{2}$-pollicaria. Sepala lanceolata acuta, $\frac{5}{8}$ poll. longa, $\frac{1}{8}$ poll. lata. Petala ovata cuspidata æquilonga, $\frac{1}{4}$ poll. lata. Labellum basi columnam amplectens; *lamina triloba, lobis lateralibus parvis oblongis falcatis, medio lanceolato-acuminato* sepalis

breviore; calcar longum pendulum clavatum, ½-pollicare. Columna apoda. Anthera angusta, longe rostrata, acuminata.

Sarawak (*Haviland* !).

CYMBIDIUM PUBESCENS, *Lindl. Bot. Reg.* (1840), *Misc.* p. 75. Peukulu Ampat, Sarawak (*Haviland* !).

The typical plant of this species is, in its very narrow leaves and shorter raceme of smaller flowers, a very different looking plant to the big broad-leaved *C. aloifolium*, Sw. (*C. Finlaysonianum*, Lindl.); but there are often plants to be met with which form connecting links between the two, and it is often difficult to separate them.

BROMHEADIA PALUSTRIS, *Lindl. Bot. Reg.* (1841) p. 89. Sintang, etc. (*Teysmann in Herb. Bogor.* !); Braang, Sarawak (*Haviland*).

B. RIGIDA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 239. Kinabalu, ad 6000 ped. alt.

DIPODIUM PALUDOSUM, *Reichb. f. Xenia Orch.* ii. p. 15. Sarawak (*Haviland*).

GRAMMATOPHYLLUM SPECIOSUM, *Blume, Bijdr.* p. 378, fig. 20. Kuching, Sarawak (*Haviland*).

PLOCOGLOTTIS LOWII, *Reichb. f. in Gard. Chron.* (1865) p. 434. Sarawak (*Haviland*).

PORPHYROGLOTTIS, gen. nov.

Caules *plures elati*, teretes, *undique foliati*. Folia *linearia acuta, graminea*. Racemi e basi exorti multiflori, floribus remotis majusculis, 1–2 simul expansi. Pedicelli longi, graciles. Bracteæ ovatæ. Sepala et petala subsimilia, elliptica lanceolata. Petala paullo latiora. Labellum *mobile unguiculatum*, ungue lineari, *laminâ* abrupte deflexâ *integrâ obovatâ*, ecallosâ pubescenti. Columna *arcuata longa*, pede brevi abrupte flexo, basi alata, brachiis duobus linearibus obtusis ad dimidium. Anthera ovata rostrata, margine clinandri tridentato. Pollinia cerea duo subglobosa, in disco quadrato cuneata.

P. MAXWELLIÆ, sp. nov. (Plate XV.)

Caules *ad 4 pedes longi*, pollicem crassi. Folia articulata graminea, 12 pollices longa, ¼ poll. lata, erecto patentia, acuminata

acuta. Racemi 3 *pedes longi*, floribus speciosis secundis. Pedicelli $1\frac{1}{2}$ poll. longi. Bracteæ parvæ ovatæ, racemo appressæ. Sepala *lanceolata acuta*, $\frac{3}{4}$ poll. longa, $\frac{3}{8}$ poll. lata, rosacea. Petala paullo breviora elliptica oblonga obtusa, paullo latiora, concolora. Labelli unguis late linearis, $\frac{3}{8}$ poll. longus, *laminâ abrupte deflexâ latâ obovatâ*, apice rotundato lato, $\frac{3}{4}$ poll. longâ, pubescenti atro-purpureo, apice flavescenti, venis pluribus elevatis ad basin. Columna $\frac{3}{4}$-pollicaris gracilis arcuata, pede brevi sursum abrupte flexo canaliculato, apice incrassato calloso, brachiis linearibus obtusis, $\frac{1}{4}$ poll. longis. Stigma grande elongatum, margine inferiore incrassato. Columna albescens, purpureo-maculata.

Sarawak (*Mrs. Maxwell*).

A single plant of this very remarkable orchid was discovered by Mrs. Maxwell, of Sarawak, in the woods of that district, and being brought home was flowered in her garden. I am indebted to Mr. H. Everett for sketches of the habit and flowers and for specimens; there is also a piece in Dr. Haviland's herbarium from the same plant.

It has the habit of a small *Grammatophyllum speciosum*, Blume, with linear-acute leaves. The racemes spring from the base of the plant and bear numerous flowers, which, however, open only one or two at a time. When fully open, the pinkish sepals and petals are deflexed. The lip is large and dark purple; it is provided with a long narrow movable claw, which is affixed to the underside of the extremity of the foot of the column. The column resembles that of *Chrysoglossum*, having two linear arms projecting from the sides halfway up. The foot of the column is channelled and ends in a semicircular transverse thickened portion. The anther-cap I have not seen, but from the drawings it appears to be ovate, beaked, and yellow. The pollen-masses are globose, seated on a brown quadrate disc, broadest at the upper end. The stigma is unusually large and long. From the back of the clinandrium rise three teeth, of which the middle one, evidently the filament of the anther, is the longer. What appears to be the rostellum is a small linear process projecting above the stigma.

I think there can be no doubt but that the affinity of this plant is with *Chrysoglossum*; the column and pollinia evidently belong to that section. The habit, as I have said, is that of *Grammatophyllum* or *Dipodium paludosum*, Reichb. f.

LUISIA BRACHYSTACHYS, *Blume, Rumphia*, iv. p. 50, is a native of Borneo according to Blume.

L. ANTENNIFERA, *Blume, l. c.* Martapura, S. Borneo (*Korthals*).

ADENONCOS VIRENS, *Blume, Bijdr.* p. 381. Mangrove swamps, Selabat (*Haviland*).

A common mangrove-tree epiphyte in Singapore. I do not see that it can belong to the genus *Microsaccus*, to which it is referred by Sir Joseph Hooker in the 'Flora of British India.' The base of the lip is a little depressed, but there is no spur. It has yellowish-green flowers with a strong scent of Friar's balsam.

PHALÆNOPSIS CORNU-CERVI, *Blume & Reichb. f. in Hamb. Gartenz.* xvi. (1860) p. 116. Sarawak!

P. VIOLACEA, *Teysm. & Binn. in Tijdschr. Nederl. Ind.* xxiv. (1862) p. 320. Pontianak, Sintang (*native collectors*).

P. SUMATRANA, *Korth. & Reichb. f. in Hamb. Gartenz.* xvi. (1860) p. 115. With the last.

P. MACULATA, *Reichb. f. in Gard. Chron.* (1881), II. p. 134. Sarawak (*C. Curtis, Haviland*).

P. MARIÆ, *Burbidge in Warn. Orch. Album*, ii. t. 80. Pontianak! (*native collectors*).

P. PANTHERINA, *Reichb. f. in Bot. Zeit.* xxii. (1864) p. 298. An ill-described species from Borneo.

P. AMABILIS, *Blume, Bijdr.* p. 294, fig. 44. Sarawak! The locality from which this plant is usually imported is the Tembilan Islands lying west of Borneo, rather more than halfway between Rhio and Borneo. Several forms are to be met with here, including var. *aurea*, with more yellow on the lip and on the base of the sepals; and a pure white form with no yellow even on the lip.

TRICHOGLOTTIS RETUSA, *Blume, Bijdr.* p. 360, fig. 8. Sarawak (*Haviland*).

T. CALCARATA, sp. nov.

Caulis rigidus, elongatus, internodiis pollicaribus. Folia *oblonga obtusissima* retusa mucronulata, ferme 3 pollices longa, $\frac{3}{4}$ poll. lata, vaginis multicostatis, ore integro. Racemi brevissimi,

$\frac{1}{4}$-pollicares, pauciflori. Flores parvuli. Sepala lanceolata acuta, lateralia $\frac{3}{8}$ poll. longa, in mentum $\frac{1}{4}$ poll. longo producta. Petala linearia acuta æquilonga, virescenti-flava rufo-tincta. Labellum album porrectum, sepalis æquale, *lobis lateralibus angustis curvis* acutis, *lobo medio lanceolato acuto*, apice sursum curvo, superne barbatum, subtus ad apicem mamillâ parvâ, *callo inter lobos lateralibus conico* obtuso flavo. Calcar *longum, gracile*, pendulum, $\frac{1}{4}$-pollicare. Columna brevis, crassa, rufa. Capsula cylindrica, 2 pollices longa, latere uno fisso.

Sarawak (*Haviland*). Remarkable for the length of the spur.

RENANTHERA TRICHOGLOTTIS, sp. nov.

Caulis validus, $\frac{1}{4}$ poll. crassus, teres. Folia *lorata* acuta angusta, apice inæqualiter bifida, laciniis acutis, 7 pollices longa, $\frac{1}{2}$ poll. lata, vaginis 2 pollices longis profunde fissis. Racemus brevis erectus, pollicaris, circiter 5-florus, bracteis persistentibus ovatis obtusis. Flores majusculi, pedicellis pollicaribus. Sepala *spathulata* obtusa, $\frac{3}{4}$ poll. longa, $\frac{1}{4}$ poll. lata. Petala *angustiora falcata spathulata*. Labellum $\frac{1}{4}$-pollicare, *lobis lateralibus oblongis* obtusis *falcatis, lobo medio carnoso lateraliter compresso apice quadrangulari-clavato, lobulis linearibus duobus obtusis* patentibus hirsutis, *juxta lobos laterales*. Calcar dependens *rectum breviusculum* inter lobos laterales, ore hirsuto. Columna curva crassa; stelidia majuscula lata. Anthera depressa, bilocularis. Pollinia 2, subtriangularia, pedicello late oblongo bidentato tenui, disco maximo ovato rotundato, margine sinuato. Rostellum bilobum, lobis rotundatis deflexis, brevibus; stigma tegens.

Limestone rocks, Sarawak (*Haviland*).

It is not easy to refer this plant to any genus. In the form of the sepals and petals it resembles such a *Vanda* as *V. insignis*, Blume, but is not so firm in texture. The lip is quite distinct from that of any *Vanda*. The spur opens between the two lateral lobes of the lip and not at the base, and in this and the form of the lateral lobes it resembles *Renanthera*, but the mid-lobe is that of a *Trichoglottis*. At its base are two linear spreading pubescent lobes. In front it is pinched up and thickened like that of some *Phalænopsis*; a groove runs along the ridge and ends in a raised portion, while the apex is deflexed so that the lip is thickest at the end. The column is longer and slenderer than usual in this group, and the pollen-masses are borne on an oblong pedicel ending in an unusually large disc.

I have no note as to the colour of this striking plant, but the sepals and petals appear to have been green or yellow with brown blotches.

The whole of this group of *Sarcantheæ*, including *Vanda*, *Renanthera*, *Arachnanthe*, and *Trichoglottis*, require to be completely rearranged, and I think more equitably broken up.

RYNCHOSTYLIS RETUSA, *Blume, Bijdr.* p. 286, t. 49. Loc. incert. (*Gibson* !); Sarawak (*Haviland*).

AËRIDES ODORATUM, *Lour. Fl. Cochinch.* p. 525. Sarawak (*Gibson* !).

Aë. Reichenbachii, Linden, Lindenia, i. t. 1, appears to be a variety of this, as is probably also the imperfectly described *Aërides Lobbii*, Teysm. & Binn. (*non aliorum*).

VANDA HOOKERIANA, *Reichb. f. in Bonplandia*, iv. (1856) p. 324. Sarawak (*Haviland*).

RENANTHERA LOWEI, *Reichb. f. Xenia Orch.* ii. 42. Pontianak! Sintang! *V. v.* The var. ROHANIANA grows with it, but is said to be much scarcer.

SACCOLABIUM PACHYGLOSSUM, *Lindl. in. Journ. Linn. Soc.* iii. (1859) p. 34. Collected in Borneo by Lobb; I have not met with it.

S. HENDERSONIANUM, *Reichb. f. in Gard. Chron.* (1875) II. p. 356. Pontianak, Sintang (*native collectors*).

S. BORNEENSE, *Reichb. f. in Gard. Chron.* (1881) I. p. 563. Not seen by me.

S. CRASSUM, sp. nov.

Caulis validus, 9-pollicaris, crassus. Folia coriacea *oblonga lorata*, 6 pollices longa, $1\frac{1}{2}$ poll. lata, apice inæqualiter biloba, lobis obtusissimis, vaginis $\frac{3}{4}$-pollicaribus superne dilatatis costatis. Racemus ultra 8-pollicares, basi nudus, bracteis ovatis exceptis, rhachide crassâ. Flores *mediocres plurimi* congesti. Bracteæ lanceolatæ acuminatæ, $\frac{1}{8}$ poll. longæ. Sepala ovata, posticum subacutum, lateralia obtusa obliqua $\frac{1}{4}$-pollicaria. Petala oblonga obtusa minora. Labelli *lobi laterales* erecti *oblongi obtusissimi, columnam superans, medius* paullo longior *linearis carnosus*, apice obtuso tenuiore. Calcar *longum*, $\frac{3}{8}$-pollicare,

pendulum *clavatum uncatum.* Columna brevis, crassa. Stelidia uncata. Pollinia globosa, pedicello hyalino tenui apice dilatato, inferne subtereti; discus minutus ovatus.

Near Kuching, Sarawak (*Haviland*).

A strong stout plant, of the *Speciosæ* section, with rather small flowers.

SACCOLABIUM PUBESCENS, sp. nov.

Caulis 6-pollicaris, crassus. Folia crassa lorata obtusissima, inæqualiter biloba, 4–12 pollices longa, 1–2 poll. lata. Panicula *gracilis* erecta axillaris, ad 15 pollices longa, basi vaginis paucis brevibus exceptis nuda, superne laxe paniculata, ramis patentibus 7 remotis raro iterum ramosis, *rhachidibus pubescentibus*, $2\frac{1}{2}$ pollices longis. Flores *perparvi* violascentes *copiosi congesti.* Bracteæ vix $\frac{1}{16}$-pollicaris, ovatæ acuminatæ acutæ. Sepalum *posticum oblongum loratum*, lateralia decurva subspathulata falcata obtusa. Petala *angustiora spathulata.* Labelli *lobi laterales oblongi vix distincti*, obtusi, *medius brevis, linguæformis* obtusus, *pubescens.* Calcar *majusculum*, versus apicem dilatatum. Columna brevis, crassa. Anthera depressa, margine antico acuto. Pollinia globosa 2, pedicello elongato lineari, disco ovato lanceolato. Rostellum prolongatum sigmoideum, sursum curvum. Stigma grande, profundum, subtriangulare.

Kuching, Sarawak (*Haviland*). *V. v.*

A living plant was sent me of this curious species from Hongkong Botanic Gardens with other Bornean Orchids. In its panicled inflorescence it more clearly resembles a *Cleisostoma* or *Sarcanthus.* But I do not see the partition in the spur characteristic of these genera. The pubescence of the rachis too is unusual. The lateral lobes of the lip are indistinct, merely forming the walls of the entance to the spur. The spur is fairly large and curved forwards.

CLEISOSTOMA SPICATUM, *Lindl. Bot. Reg.* (1847) sub t. 32. I have received living plants from Sarawak from native collectors.

C. CRASSUM, sp. nov.

Caules *breves*, bipollicares, lati. Folia 5–6 flaccida *coriacea*, 12 pollices longa, $2\frac{1}{2}$ pollices lata, *oblanceolata obtusa*, apicibus breviter inæqualiter bilobis. Racemi *densi, foliis breviores*, 5 pollices longi, ex axillis inferioribus, rhachidibus crassis teretibus,

basi $1\frac{1}{2}$-pollicari nudi. Flores parvi copiosi congesti, breviter pedicellati, pedicellis $\frac{1}{8}$-pollicaribus crassis. Bracteæ æquilongæ lanceolatæ acuminatæ, pedicellis appressæ. Sepala oblonga subacuta, $\frac{1}{8}$-pollicaria. Petala subæqualia spathulata, omnia flava, maculis aut striis rubris ad basin, pubescentia. Labellum flavum, breve; lobi laterales paullo elevati rotundati, lobus medius ovatus linguiformis. Calcar latum scrotiforme, pedicello æquale; *calli* 3, *unus laminæformis* oblongus e basi labelli, *alteri laminæ subquadratæ* e basi lobi medii. Columna crassa brevis, clinandrio haud profundo. Anthera ovata rostrata, rostro sursum curvo. Pollinia 2 obovoidea, pedicello lineari gracili longo, disco triangulari-ovato.

Borneo (*loc. incert.* Native collector. Cultivated in Hort. Bot. Singapore, 1890–93).

This is a stout plant, with large, broad, rather thin leaves, strongly articulated with their sheaths which project an inch beyond the stem. The racemes are stout and dense. Flowers small, bright yellow with red markings. The lateral sepals curl round so as to embrace the lip and almost meet round it. There are three calli in the mouth of the straight stout spur; one springs from the base of the lip in the form of a thin oblong lamina, the others from the sides between the base of the midlobe and the ends of the lateral lobes. These calli meet so as to close over the mouth of the spur.

DENDROCOLLA FUSCA, sp. nov.

Caulis circiter bipollicaris. Folia approximata *lineari-lanceolata* anguste acuminata acuta, apice inæqualiter bilobo, 4 pollices longa, $\frac{1}{2}$ poll. lata, atro-viridia coriacea canaliculata, vix distincte carinata, vaginis brevibus teretibus. Racemi 1–2 in axillâ, compressi undulati, undique bracteati, rhachide supra bracteis excavatâ. Bracteæ basi vaginantes laminâ acutâ. Flores distichi parvi, singulatim expansi, pedicellis gracilibus. Sepalum posticum oblongum acutum virescens, apice purpurascente, lateralia majora ad basin columnæ adnata oblique ovata mucronata, virescentia, apicibus purpurascentibus. Petala minora angusta lanceolata, pallide virescenti-purpurea. Labellum basi angustum oblongum album, margine roseo, calcare porrecto obtuso, apice recurvum lateraliter compressum album, *lobis lateralibus acutis recurvis* roseis ad basin, *lobo medio ovato calliformi parvo.* Columna brevis crassa, clinandrio profundo. Anthera ovata. Pollinia 2, globosa, pallide flava, pedicello apice dilatato oblongo

eroso, lineari, lato, disco triangulari-ovato. Rostellum lineare, bifidum, apicibus acuminatis.

Borneo (*loc. incert.* Native collector. Cultivated in the Botanic Gardens, Singapore, April 1890).

This belongs to the genus *Dendrocolla* I think, but the raceme is not nude at the base but floriferous for its whole length. The spur-like portion of the lip is rather long, and projects forwards.

SARCOCHILUS VRIESII, sp. nov.—Pteroceras, sp., *De Vriese, Illustr.* t. 9. fig. 5.

Caulis 3–6 pollices longus, radicibus elongatis. Folia dissita lorata coriacea lucida, 4 pollices longa, pollicem lata; vaginis teretibus, $\frac{1}{2}$-pollicaribus. Racemi 2–3, e basibus vaginarum extrusi, 3–6 pollices longi, basi nudi teretes. Bracteæ *rhachide appressæ*, virides, *ovatæ, obtusæ*, breves. Flores explanati, circiter $\frac{1}{2}$ poll. lati, 1–2 simul expansi, pedicellis $\frac{1}{2}$ poll. longis. Sepala æqualia ovata obtusa. Petala paullo minora, omnia læte flava, maculis kermesinis ad basin. Labellum *unguiculatum, ungui lineari*, lobis lateralibus parvis rotundatis erectis, *lobo medio calliformi, calcare basi subgloboso, apice cornuto sursum curvo*, marginibus loborum lateralium, maculis, et apice calcaris kermesinis. Columna brevis crassa, superne dilatata subglobosa, virescens. Clinandium parvum depressum, marginibus crassis. Anthera late ovata depressa, apice obtuso. Rostellum breve, lineare, bifidum, lobis acutis. Stigma parvum, circulare, profundum.

Pontianak (*native collector. V. v.* April 1890).

I have no doubt that the figure of De Vriese's above referred to is intended for this curious and pretty plant. He gives no description nor figures of details, I cannot find that any description has ever been published of the species; but Reichenbach unaccountably (in Walpers's Annales, vi. p. 498) refers this figure to Blume's *Dendrocolla compressa*, which he renames *Sarcochilus compressus* without giving any diagnosis. Blume's description is too meagre to give any idea of what he intended, but it is perfectly clear that this was not the plant he had in his mind, for he describes the leaves as linear-lanceolate and the peduncle as compressed, showing that it was evidently one of the *Thrixsperma*.

S. Vriesii is a pretty but not showy plant, remarkable for the form of the lip, the lateral lobes of which are small and erect; between them is a callus-like body which represents the mid-lobe.

The spur is porrect as in the rest of the genus, globose almost at the base, and then tapering off into a rather long upcurved horn which is tipped with crimson. The petals and sepals are widely spread and of a golden-yellow colour, their bases dotted with crimson spots, so that there is a circle of spots all round the column and lip. Only a few flowers are open at a time on the pendent rhachis in the plants I have seen, but De Vriese's figure gives a number expanded. His plant, however, was evidently a very fine specimen. I have seen another plant much like this from Manila, with a very much longer lip bifid at the apex.

SARCOCHILUS UNGUICULATUS, *Lindl. Bot. Reg.* (1840), *Misc.* p. 67, was sent from Borneo by Mr. Durnford. It is also a native of the Philippines.

S. SIGMOIDEUS, sp. nov.

Caulis crassus brevis, 3 pollices longus, radicibus albescentibus. Folia 8 pollices longa, $2\frac{1}{2}$ pollices lata, oblonga lorata coriacea deflexa obtusissima. Racemus 3-pollicaris, basi nudus, bracteis parvis appressis exceptis, *superne incrassatus*, multiflorus, floribus 1–2 simul expansis, fugacibus. Bracteæ parvæ ovatæ, $\frac{1}{16}$-pollicares, acutæ, purpureæ. Pedicelli crassiusculi, $\frac{1}{2}$ poll. longi. Sepalum posticum $\frac{1}{4}$ poll. longum, oblongum obtusum, lateralia latiora obliqua. Petala lanceolata obtusa, omnia alba, maculis et fasciis roseis. Labellum sepalis brevius, album, sigmoideum, *lateraliter complanatum*, basi angustâ lateribus erectis, *epichilio* haud distincto *ovato acuto, callis duabus* in lateribus loborum lateralium, calcare antrorsum spectante *sigmoideo*, apice incrassato obtuso. Columna alta apoda superne dilatata alba, clinandrio plano haud depresso. Anthera ovata rostrata. Pollinia 2, subreniformia, pedicello cuneato oblanceolato, disco parvo scutiformi. Stigma oblongum. Rostellum breve, bifidum.

Pontianak (*native dealer*).

This is really most closely allied to *Saccolabium*, but it has the long column of *Sarcochilus*. The lip is not easy to describe. There is no distinction between the lateral lobes and epichil, the sides are raised and enclose a narrow passage to the spur; below the opening is an ovate acute limb which is evidently the epichil, and just above this there is a callus on each side of the channel between the two walls formed by the lateral lobes.

THRIXSPERMUM LILACINUM, *Reichb. f. Xenia Orch.* ii. p. 121. Kuching, Sarawak (*Haviland*).

THRIXSPERMUM BORNEENSE, *mihi.*—Sarcochilus borneensis, *Rolfe in Illustr. Hortic.* xxxix. (1892) p. 99, t. 161. Borneo (*Low in Herb. Kew*).

T. LONGICAUDA, sp. nov.

Caulis eo *T. lilacini* similis, *elongatus validus* teres, internodiis 1½–2 pollices longis. Folia 1½–2 pollices longa, pollicem lata, oblonga elliptica obtusissima, vaginis costatis. Pedunculi ultra 6 pollices longi patentes, bracteis ut in *T. lilacino.* Flores iis *T. Arachnitis* similes *sed majores,* pedicellis ¾ poll. longis Sepala ad bases lanceolata *longe caudata,* 3-pollicaria. Petala angustiora æquilonga. Labellum stipitatum vix pollicare, lobis lateralibus falcatis obtusis, medio ovato acuto, *callo nullo.*

Sarawak, on limestone rocks (*Havilana*).

An ally of *T. Arachnites,* Reichb. f., from which it differs in the elongate stem and much longer sepals and petals. From *T. Scopa,* Reichb. f., it is distinguished by the size of the sepals and petals and by the smooth lip without any callus.

T. ARACHNITES, *Reichb. f. Xenia Orch.* ii. p. 121. Sarawak (*Haviland*).

ACRIOPSIS JAVANICA, *Reinw. ex Blume, Gew. Buitenz.* p. 97; *Bijdr.* p. 377. Sarawak (*Haviland!*).

A. PURPUREA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iii. (1893) p. 406. Kuching, Sarawak (*Haviland!*).

THECOSTELE ZOLLINGERI, *Reichb. f. in Bonplandia,* v. (1857) p. 37. Sarawak (*Haviland!*).

T. SECUNDA, sp. nov.

Pseudobulbi congesti ovoidei oblongi, olivacei, costati et canaliculati curvi paullo compressi, 1½ pollices longi, pollicem lati. Folia tenuiter coriacea atro-viridia, 8 pollices longa, 1½ pollices lata, lanceolata subacuta carinata et canaliculata. Scapi breves, 3-pollicares, penduli. Flores circiter 10 *mediocres, secundi.* Bracteæ ovatæ appressæ purpurascentes, ⅛-pollicares. Sepalum posticum curvum gibbosum acutum cymbiforme, flavescenti-viride, apice rufescenti, lateralia lata ovata acuminata, ½ poll. longa, ⅜ poll. lata, viridia, fasciâ singulâ rufâ ad basin. Petala linearia lanceolata acuta viridia, fasciis tribus rufis. Labelli unguis planus, apice latior, hic abrupte flexus albis marginibus; *lobi laterales oblongi rotundati* erecti, marginibus incurvis

olivaceis, intus glanduloso-pubescentes rufi, carinis *elevatis lamelliformibus* albis, inter eos pubescentibus, *lobo medio ovato acuto*, haud unguiculato albo, callo *mammillari*, flavescenti-purpureo, marginato ad basin (prope apices carinarum) maculâ violaceâ pubescenti in disco. Columna valde arcuata purpurascens, stelidiis latis linearibus obtusis, pede elongato subtereti, albo, dentibus nullis. Anthera conica elongata, purpurea, antice flava, apice obtuso, margine rotundato. Pollinia 2 aciniformia acuta, pedicello unico, plano, apice dilatato. Rostellum grande triangulare, album.

Sarawak (*H. Everett*!). Also in Perak, Malay Peninsula, *v.v.*

This very curious plant is an ally of *Thecostele Maingayi*, Hook. f., but differs in the flowers being secund and in the form of the lip, which in the latter (as figured in the 'Icones Plantarum,' t. 2118) has two hooked processes replacing the lamellæ between the two lateral lobes, and no callus in front of them. There is a figure of evidently the same plant among Scortechini's drawings, and I saw it also alive in a garden in Thaiping, Perak.

In describing this species I have called the tubular nectary running from the base of the erect portion of the column, the column foot, although I have little doubt but that it consists partly of column and partly of the claw of the lip. A comparison with the allied genus *Acriopsis* gives the key to the structure of the lip and column of *Thecostele*. In *A. javanica*, Reinw., the base of the lip is adnate by its margins to the margins of the column. This portion is erect in *Acriopsis*, horizontal in *Thecostele*, the upper part of the column being much prolonged and arched over the horizontal nectary. This being so, the small divisions at the base of the lamina (represented as hooked in *T. Maingayi*, ic. cit.) represent the lamellæ of the disc of *Acriopsis* and not the lateral lobes. Indeed, in *T. Maingayi*, Hook. f., they are figured as rising from between the larger rounded lobes and not behind them. Comparison with other species of *Thecostele* show this quite clearly. The lateral lobes are erect rounded bodies, and the mid-lobe is ovate. The pollinia are very different from those of *T. Zollingeri*, Reichb. f.; they are almost spindle-shaped and acute at the apex, and borne on a single narrow flat pedicel, dilated at the apex. In *T. Zollingeri*, Reichb. f., they are more globose and borne on two distinct pedicels ending in a large disc. In *T. Maingayi*, Hook. f., the

pollinia are stated to be four, "terminating a long narrow strap dilated upwards and with a glandular base.'

PODOCHILUS SIMILIS, *Blume, Rumphia*, iv. p. 44. Kuching, Sarawak (*Haviland*).

P. MICROPHYLLUS, *Lindl. in Wall. Cat.* n. 7335 A. Sarawak (*Haviland*).

P. LUCESCENS, *Blume, Bijdr.* p. 295, t. 12. Baram (*C. Hose*); Sarawak (*Haviland*).

P. UNCIFERUS, *Hook. f. Fl. Brit. Ind.* vi. p. 81. Sarawak, Limestone Hills (*Haviland*).

APPENDICULA CALLOSA, *Blume, Bijdr.* p. 303. Sarawak (*Haviland*); Baram (*Hose*).

A. REFLEXA, *Blume, l. c.* p. 301. Trusan River (*Haviland*).

A. TORTA, *Blume, l. c.* p. 303. Limestone rocks, Sarawak (*Haviland*).

A. BIFARIA, *Lindl. in Hook. Kew Journ.* vii. (1855) p. 35. Sarawak (*Haviland*).

A. XYTRIOPHORA, *Reichb. f. in Seem. Fl. Vit.* p. 299. Sarawak (*Haviland*).

A. PENDULA, *Blume, Bijdr.* p. 298. Matang Waterfall, 800 feet alt.; Sarawak (*Hallett*) (*Haviland*). I have it also in cultivation from Borneo.

What I take to be Blume's *A. pendula* is the biggest of all the *Appendiculas* known to me. It is upwards of three feet high and proportionally stout. The racemes are lateral or terminal and sometimes produced on old stems from which the leaves have fallen; they have a stout rhachis, which slowly lengthens as the flowers open one by one, and it eventually attains a length of 8 inches. The flowers are fairly large for the genus, about $\frac{1}{8}$ inch across, petals and sepals light green. The lip short and broad, white, ovate, pandurate blunt; two large but little elevated wings at the base end in a thickened boss on the terminal portion of the lip, the upper edges of these wings and of the lip itself are purple. The column is short and thick, with a violet clinandrium and violet streaks on the front. Stelidia obscure. Pollinia very unequal, 8, elongate. Anther ovate, acute, orange. Capsule $\frac{3}{4}$ inch long.

A. lancifolia, Hook. f., is an ally of this.

APPENDICULA CALCARATA, sp. nov.

Elata, ramosa, ad 18-pollicaris, radicibus copiosis Caules compressi. Folia plurima *oblonga obtusa* obscure biloba, mucrone nullo, ferme pollicem longa, $\frac{1}{4}$ poll. lata, vaginis $\frac{1}{2}$-pollicaribus profunde fissis. Racemi *terminales*, $1\frac{1}{2}$-pollicares. Bracteæ foliaceæ, flores superantes, lanceolatæ falcatæ, $\frac{3}{4}$-pollicares, obtusæ. Flores pro genere majusculi. Sepalum posticum lanceolatum acutum, 5-nervium mucronatum, lateralia æquilonga lanceolata acuminata acute carinata, longe connata, mentum *longum subacutum* pendulum rectum $\frac{1}{4}$-pollicare formantia. Petala lanceolata acuta breviora, 5-nervia, nervis (ut videtur) kermesinis, marginibus kermesinis. Labellum *longum angustum*, apice dilatato *rotundato crispo*, callo *longo oblongo* ad basin, lamellis *semiovatis majusculis* versus apicem. Columna brevis, longipes. Anthera lanceolata, longe rostrata, bilocularis. Pollinia 6, oblique clavata; pedicellis 2, linearibus, polliniis æqualibus, disco parvo lineari. Rostellum longum, lineare, apice bifido, lobis acutis. Alæ columnæ majusculæ. Stigma productum, cymbiforme.

Sarawak (*Haviland*).

This species belongs to the section with strictly terminal inflorescence. The bracts are large and leaf-like, and much longer than the flower, which is fairly large for the section. The spur composed of the prolonged bases of the sepals is remarkably long and lies parallel to the ovary. The pollinia are six, and supported on long pedicels. Perhaps no genus has such variation in the form and number of pollinia as has *Appendicula* as it is usually defined. They seem to vary in number from four to eight; they may be attached to one (*A. bifaria*, Lindl.) or two (*A. calcarata*) distinct pedicels, or may have, strictly speaking, no pedicels at all, the pollen-masses being arranged in two clusters and attached by their points independently to the disc.

A. CONGESTA, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 239. Kinabalu, Penokok, 4000 ped. alt. (*Haviland*).

A. FRUTEX, sp. nov.

Caules *ramosi erecti*, undique foliati teretes, ultra 6-pollicares. Folia approximata *elliptica* oblonga, $\frac{1}{2}$–$\frac{3}{4}$ poll. longa, $\frac{1}{4}$ poll. lata, obtusa, inæqualiter biloba, vaginis semiamplectentibus, $\frac{1}{4}$-pollicaribus. Racemi brevissimi, laterales vel terminales pauciflori. Bracteæ lanceolatæ acuminatæ acutæ, $\frac{1}{8}$ poll. longæ, pallidæ. Flores parvi, flavescentes. Sepalum posticum ovatum

lanceolatum, nervis tribus elevatis, lateralia ovata triangularia multo majora. Petala linearia, obtusa, rufo-striata. Labellum *liberum obovatum* obtusum, *obscure crenulatum*, margine ad basin incrassato. Columna brevis, pede longo. Anthera lanceolata obtusa, unilocularis. Pollinia 6, lanceolato-fusiformia, 2 minora, pedicello distincto minuto, disco cordato minutissimo. Rostellum elongatum oblongum, apice bifido. Stigma basi producto poculiformi.

Sarawak, Pengkula Ampat (*Haviland*). "Flower yellow, striped red."

A rather bushy plant, with ascending branches. The flower in general appearance resembles that of an *Aporum*, but the pollinia, rostellum, &c. are those of a true *Appendicula*. The lip has a thickened V-shaped ridge from the base running into the broader part of the lip.

Oxyanthera decurva, *Hook. f. Ic. Pl.* t. 2517; Thelasis decurva, *Hook. f. Fl. Brit. Ind.* vi. p. 87. Kuching, Sarawak (*Haviland*).

O. elata, *Hook. f. Ic. Pl.* t. 2516; Thelasis elata, *Hook. f. Fl. Brit. Ind.* vi. p. 87. Trusan River (*Haviland*).

Thelasis ochreata, *Lindl. in Journ. Linn. Soc.* iii. (1859) p. 63, was collected in Borneo by Lobb.

Neottieæ.

Vanilla albida, *Blume, Rumphia*, i. p. 197, t. 67. Sarawak (*Haviland*).

This is quite distinct from the Malay Peninsula *Vanilla*, having a longer and quite differently formed lip, and more nearly resembles Blume's figure in 'Rumphia.'

Corymbis veratrifolia, *Reichb. f. in Flora*, xlviii. (1865) p. 184. Trusan, near the Fort (*Haviland*).

Zeuxine purpurascens, *Blume, Orch. Archip. Ind.* p. 71, tt. 18, 23, was obtained in Borneo by Blume, who gives no special locality.

Hetæria obliqua, *Blume, l. c.* p. 104, t. 34. f. 1. Lake Baboy, S. Borneo (*Korthals*), *non vidi*.

DOSSINIA MARMORATA, *C. Morr. in Ann. Soc. Gand*, iv. (1848) p. 171, t. 198. Limestone rocks, Matang, Sarawak (*Haviland*).

CYSTORCHIS VARIEGATA, *Blume, Orch. Archip. Ind.* p. 89, tt. 24, 36. Trusan River; 1 mile from Kuching (*Haviland*).

C. GLANDULOSUS, *Benth. & Hook. f. Gen.* iii. p. 598, *in notâ sub* Physuro. Borneo: this I have not seen.

CYSTOPUS SPICATUS, *Blume, Orch. Archip. Ind.* p. 84. Western Borneo (*Mueller*, fide *Blume*).

CORYSANTHES FORNICATA, *Lindl. Gen. et Sp. Orch.* p. 394. In *Sphagnum*; Santabong and near Tegura, Sarawak (*Haviland*).

OPHRYDEÆ.

HABENARIA MARMAROPHILA, sp. nov.

Radices crassi, lanuginosi. Folia plura lanceolata congesta acuta, basi attenuata, tenuia, 12 pollices longa, 1¾ poll. lata. Scapus crassus elatus, 18-pollicaris vel ultra, vaginis foliaceis pluribus in bracteis superne attenuatis. Racemus laxus pluriflorus. Bracteæ lanceolatæ acuminatæ, pollicem longæ, ¼ poll. latæ ad basin, superiores minores. Flores majusculi, pedicellis quam bracteæ longioribus. Sepalum *posticum cum petalis connatum*, galeam erectam, ¼ poll. longum formans, lateralia oblonga ovata falcata deflexa. Labellum *trifidum*; *lobi lineares*, medius ultra dimidium pollicis, laterales breviores. Calcar *longum pendulum* clavatum, pollicare. Columna lata; anthera obtusa, processibus longis porrectis. Pollinia oblongo-ovoidea, pedicellis longis, tenuibus ¼-pollicaribus, discis ellipticis. Processus *rostelli elongati* porrecti, iis antheræ æquales. Stigmata subglobosa papillosa. Glandulæ laterales columnæ lamelliformes.

Buseau, Sarawak, limestone hills (*Haviland*).

A tall plant with the habit of *H. ovalifolia*, Wight.

H. BORNEENSIS, *Ridl. in Trans. Linn. Soc.* ser. II., *Bot.* iv. (1894) p. 240. Kinabalu, 10,000 ped. alt. (*Haviland*).

CYPRIPEDIEÆ.

CYPRIPEDIUM DAYANUM, *Reichb. f. in Bot. Zeit.* xx. (1862) p. 214. Kinabalu.

C. HOOKERÆ, *Reichb. f. in Hook. Bot. Mag.* t. 5362. Sarawak.

J. de Alwis del.

BULBOPHYLLUM PEDICELLATUM Ridl.

J. de Alwis del. J. N. Fitch lith.

BULBOPHYLLUM TARDIFLORENS, *Ridl.*

J. de Alwis del. ...R... GRACILIS MAXWELLII, Ridl. J.N. Fitch lith

CYPRIPEDIUM JAVANICUM, *Reinw.* ex *Blume Cat. Gew. Buitenz.* p. 98, nomen. A single plant is reported to have been introduced into England from Borneo by Messrs. Low.

C. LAWRENCEANUM, *Reichb. f. in Gard. Chron.* (1878) II. p. 748. Lawas River, Meringit!

C. LOWEI, *Lindl. in Gard. Chron.* (1847) p. 765. Sarawak! Baram River!

C. STONEI, *Hook. f. Bot. Mag.* t. 5349. Sarawak!

C. NIGRITUM, *Reichb. f. in Gard. Chron.* (1882) II. p. 102. Borneo.

APOSTASIACEÆ.

APOSTASIA NUDA, *R. Br. in Wall. Pl. As. Rar.* i. p. 76, t. 85. Penkulu Ampat, at 2000 feet alt.; Santubong, at 200 feet alt. (*Haviland*).

A. GRACILIS, *Rolfe, in Journ. Linn. Soc.* (*Bot.*) xxv. (1889) p. 242. Borneo (fide *Rolfe*).

A. LOBBII, *Reichb. f. in Flora*, lv. (1872) p. 278. Labuan (*Lobb*); Banjermassing, South Borneo (*Motley*).
I confess I am not able from description to separate these species. There is a stout broad-leaved form commonly to be met with growing with typical forms of *A. nuda*, R. Br., which may be the plant intended by *A. Lobbii*, Reichb. f. Dr. Haviland's Penkulu Ampat specimen is of this form; it is apparently only a local variety. *A. nuda*, R. Br., in all places where I have seen it, and it is very common, has white and not yellow flowers as described and figured by Wallich.

NEUWIEDIA LINDLEYI, *Rolfe, in Journ. Linn. Soc.* (*Bot.*) xxv. (1889) p. 232. Borneo (*Low* fide *Rolfe*).

DESCRIPTION OF THE PLATES.

PLATE XIII.

Bulbophyllum pedicellatum, Ridl.

Fig. 1. Entire plant, natural size.
2. Flower, enlarged.
3. Flower partially opened.
4. Column and lip.
5. Lip, front view.
6 Anther, front and side views.

PLATE XIV.

Bulbophyllum tardeflorens, Ridl.

Fig. 1. Entire plant, reduced.
2. Flower and rhachis, natural size.
3. Lip, enlarged.
4. Column, from front.

PLATE XV.

Porphyroglottis Maxwelliæ, Ridl.

Fig. 1. Entire plant, reduced.
2. Portion of flower raceme, natural size.
3. Flower, side view, natural size.
4. Column, side view.
5. Column, front view.
6. Pollinia, enlarged.
7. Pollinia, side view.

Some Remarkable Phanerogamous Parasites.

By W. BOTTING HEMSLEY, A.L.S., F.R.S.

[Read 20th December, 1894.]

WITH the permission of the Director of the Royal Gardens, Kew, I have brought specimens of some highly curious examples of parasitism of phanerogamous plants which, I think, may interest the Society. I do not pretend, however, that these are all new facts. On the contrary, I have brought together a number of interesting phenomena from widely scattered sources. I may mention, in passing, that the Loranthaceæ, the order to which most of them belong, are cosmopolitan in warm and temperate regions, and the genera *Loranthus* and *Viscm* have nearly the same range as the order, except that they are replaced by closely allied genera in North America.

The first I have to show is *Loranthus aphyllus*, Miers, a Chilian species parasitic on *Cereus Quisco*, C. Gay, one of the large columnar Cacti. These specimens were presented to Kew by Mr. J. W. Warburton, of the British Consulate General at Valparaiso, who writes to the effect that he had examined thousands of plants, and they were invariably in the same position on the host, that is to say, in the axils of the cushions of prickles or spines—the same position in which the flowers are produced. Referring to Gay's 'Flora Chilena' (iii. p. 154), I find the statement that this

species of *Loranthus* only grows on this particular species of *Cereus*, the formidable spines of which must afford some protection to the parasite. The latter has large showy berries, much larger than one would suppose from the dried specimens, if we may trust a painting in the North Gallery at Kew. This is an instance of a leafless parasite on a leafless host; and it is restricted to a comparatively limited area. The common Mistletoe, *Viscum album*, Linn., presents biological peculiarities of a totally opposite nature. As you all doubtless know, it preys upon a great variety of trees and shrubs, differing as widely in structure, properties, and foliage as the apple, Scotch fir, and dog-rose do; and its geographical range is from Scandinavia to North Africa, and from the extreme west of Europe eastward to China and Japan. It exhibits comparatively little variation throughout this wide area. Besides accommodating itself to a great variety of hosts, it possesses a faculty less generally known. The seeds will actually germinate and grow on a plant of its own kind. A specimen from Didcot, having a small seedling on one of its branches, illustrates this peculiarity. It was discovered by Mr. Corderoy, and exhibited by Dr. M. T. Masters at a meeting of the scientific committee of the Royal Horticultural Society in 1875 *. In the South of Europe, according to Pollini ('Flora Veronensis,' iii. p. 176), it is occasionally met with on the equally parasitic *Loranthus europæus*, Linn., from which it does not very widely differ in foliage †. But there are several other known instances of this biological phenomenon. *Tupeia antarctica*, Cham. & Schlecht., a New Zealand member of the Loranthaceæ, is sometimes, on the testimony of Sir James Hector, parasitic on *Loranthus micranthus*, Hook. f. The *Tupeia* is very variable in foliage; but from the specimens exhibited it will be seen that in the fruiting-stage, at least, it so closely resembles the *Loranthus* as to be hardly distinguishable. The *Tupeia* differs, however, in having a paler bark, and in the very straight unbranched axis of the inflorescence. Alive, it is more easily recognized, because it is diœcious. As might be expected from their occasional association in the manner described, they

* Dr. R. C. A. Prior read a letter from a correspondent before this Society June 17th, 1880, describing the unusual occurrence of Mistletoe growing upon Mistletoe. See Proceedings, 1875–80, p. lxi.

† It has been proved by experiment that seeds of *Viscum* will germinate on a variety of substances on which they cannot continue to grow; and in the Kew Museum there is an example, from Jamaica, of a seed of a *Loranthus* germinating on a branch of an inflorescence of the sugar-cane.

prey upon the same kinds of plants, both being common on the "mingi-mingi," *Cyathodes acerosa*, R. Br., one of the small rigid-leaved Epacrideæ. But a much more remarkable instance of double parasitism is offered by the genus *Phacellaria.* This is a genus of leafless parasites belonging to the Santalaceæ; and all the specimens in the Kew Herbarium of the three or four species known are parasitic on various leafy species of *Loranthus.* I described a species discovered in Burma by Sir Henry Collett, in our Journal (vol. xxviii. p. 122, pl. xvii.). The specimen is not actually attached to the host-plant; but Sir Henry noted in the field that such was the case. I have shown you examples of leafy parasites growing on other leafy parasites, and also of leafless parasites growing on leafy parasites; but I have not met with any instance of two leafless parasites being associated in the same manner. The principal genera of Loranthaceæ—*Loranthus, Viscum, Phoradendron, Arceuthobium*—have both leafy and leafless species; and it frequently happens that the leaves of the leafy species are so like those of the host-plant, that, like *Tupeia,* they are indistinguishable except on very close examination. The common Mistletoe, which grows on such a great variety of trees and shrubs, presents, so far as I know, no striking similarity in foliage to any one of its hosts. On the other hand, one of the commonest Australian species of *Loranthus* (*L. pendulus,* Sieber) mimics, if I may use the term, the foliage of more than one of the plants upon which it preys so closely that branchlets of host and parasite might pass for the same. The specimen of a variety of *Loranthus pendulus* side by side with one of its host-plants, *Eucalyptus amygdalina,* Labill., is a striking instance; and every one will agree that when not in flower it might escape the notice of the most acute observer. The essential difference is, that the parasite has opposite leaves and the host alternate leaves. Another of the host-plants of *Loranthus pendulus* is *Fusanus spicatus,* R. Br., a member of the Santalaceæ. This has opposite leaves; and is otherwise so like the parasite that, with the specimens before you, it is sufficient to point out the fact. Whether these resemblances are due to association or to local climatal conditions favourable to the development of the same type of foliage, I am not prepared to say. It is equally impossible for me to judge whether the parasite derives any benefit or protection from the resemblance. Rather than speculate on the subject, I prefer leaving its elucidation to those who have opportunities of studying the conditions and relationships of the plants in the living state. Some of the parasites

which mimic the host appear to be confined to one species, or to very closely allied species; but on this point more exact information s required. It is certain, however, that *Loranthus pendulus* not only grows on various species of *Acacia*, *Eucalyptus*, and *Santalum*, plants having very similar foliage, but it also grows on various species of the exceedingly dissimilar genus *Casuarina*. Although I am not able to show you specimens actually attached to the host-plant, I believe that the authorities are implicitly reliable.

I will now return to the genus *Viscum*, and to what I believe is the smallest species, *Viscum minimum*, Harv. It grows on the *Cereus*-like species of *Euphorbia*, and perhaps exclusively on the *E. cereiformis*, a species having itself a close resemblance to the genus *Cereus*, except in the arrangement of the spines. This tiny parasite is scarcely a quarter of an inch high, and the most fully developed plants have only three flowers, two lateral and one terminal, succeeded by berries which individually are many times larger than the plant bearing them *. *Viscum Crassulæ*, Eckl. & Zeyh., is another interesting South-African species, concerning which I find the following note accompanying a specimen in the Kew Herbarium presented by Professor MacOwan, Government Botanist, Cap Colony:—"This rare *Viscum* grows plentifully between Cockhuis Drift on Vischrivier and Patryshoogte, but invariably on *Portulacaria afra*, Jacq., whose younger leaves it strikingly resembles. But for the scarlet berries, few save botanists would detect it. The large arborescent *Crassula portulacea*, Lam., is abundant in the same locality; but though I have examined hundreds of trees the *Viscum* has never occurred upon any. Some sharp-eyed Boers say it grows on the Groot Noors Doorn; but this may be a remembrance of the large scarlet-berried *V. minimum*."

I might go on multiplying instances in which strong resemblances between the foliage of the host and the parasite exist; but I will only put forward one more. This is the Indian *Loranthus longiflorus*, Desr., growing on the Mango. Compare the parasite and host as represented in an unpublished drawing of the *Loranthus* and the 'Botanical Magazine' figure of the Mango, t. 4510.

As an illustration of the diversity in size of the flowers, I call your attention to the figure of *Loranthus macranthus* (Hooker's

* A still more diminutive parasite of this order is *Arceuthobium minutissimum*, which grows on the branches of *Pinus excelsa* in North-west India. The flowers are practically sessile on, or even almost embedded in, the bark.

'Icones Plantarum,' viii. t. 743), a native of the Andes, having flowers nearly a foot long, as against those of *L. europæus*, though there are others with much smaller flowers.

Another remarkable species is *L. Beccarii*, King, a native of Malaya. The flowers are in crowded heads, within an involucre of highly coloured bracts, resembling some of the showier species of *Mutisia* (Compositæ) before the heads have expanded.

I will now say a few words about some of the parasites of the natural order Rafflesiaceæ. The flowers of the species of *Rafflesia*, including the gigantic *R. Arnoldi*, R. Br., are sessile on the roots of various species of *Vitis*, springing from a mycelium-like tissue that permeates the matrix; but I do not propose touching on the larger province of root-parasites. The other members of the order are mostly parasitic on the branches of shrubs and trees, only the flowers appearing externally.

To illustrate this order of parasites, I have brought two species of *Pilostyles*. This genus, as distinguished from the allied *Apodanthes*, which has been united with it by some botanists, invariably preys on members of the Leguminosæ; *Apodanthes* on *Casearia* and *Flacourtia*. *Pilostyles* consists of about ten species inhabiting very distant parts of the world; and the plants appear as sessile flowers on the host-plants. *Pilostyles Haussknechtii*, Boiss., is parasitic on various spiny species of the genus *Astragalus* inhabiting Persia and the adjoining countries. The peculiarity of this species is that its flowers appear one on each side of the base of the petioles of the leaves of the host-plant. The seeds germinate in the tips of the shoots and the thallus, or mycelium-like tissue penetrates the tissues of the host, emerging only where the flowers are formed, the only emergencies being the flowers with a few subtending bracts at their base.

I have mentioned that some botanists unite *Pilostyles* with *Apodanthes*, but I am convinced that Count Solms is right in keeping them separate. He distinguishes them as follows:—

Perianth consisting of four deciduous, subepigynous, clawed segments .... *Apodanthes*.
Perianth consisting of free segments, with a broad base, persisting until the fruit is ripe .... *Pilostyles*.

Besides these structural differences, which are not very great, it is true, there is the fact that *Apodanthes* is parasitic on the allied genera *Casearia* and *Flacourtia*, whilst, so far as is known, all

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4. No work forming part of Linnæus's own Library shall be lent out of the Library under any circumstances.

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A GENERAL INDEX to the first twenty volumes of the Journal (BOTANY) and the Botanical portions of the Proceedings from November 1838 to June 1886 may be had on application, in cloth, or in sheets for binding. To those who have been elected Fellows of the Society subsequent to its publication in 1888, the price is 15*s.*

NOTICE.

Vols. XXVI. & XXXI. are in course of simultaneous issue to expedite the publication of papers, and the Parts already published are as follows:—

Vol. XXVI., Nos. 173–177.

(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

Vol. XXVII., Nos. 181–188. (Complete.)

Vol. XXVIII., Nos. 189–196. (Complete.)

Vol. XXIX., Nos. 197–204. (Complete.)

Vol. XXX., Nos. 205–211. (Complete.)

Vol. XXXI., Nos. 212–214 and 215 (the present Part).

Attention to this announcement is specially requested, to prevent application to the Librarian for unpublished Parts.

The Anniversary Meeting adjourned from May 25th will be held on June 4th at 8 p.m., and the last Meeting of the present Session will be held on June 18th, when the Chair will be taken at 8 p.m. as usual.

JUNE 11. Price 3s.

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VOL. XXXI. BOTANY. No. 216.

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1896.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

the species of *Pilostyles* are restricted to the Leguminosæ, though preying on members belonging to the most widely separated tribes of that order. Below is a list of the species with the names of the plants on which they occur and their native countries. Like most parasitical types, they have a wide range, *Pilostyles* being represented in Asia, Africa, and North and South America.

Name.	*Parasitic on*	*Native Country.*
Apodanthes Caseariæ, *Poit.*	Casearia sylvestris.	Brazil.
„ Flacourtiæ, *Karst.*	Flacourtia sp.	Venezuela.
Pilostyles Haussknechtii, *Boiss.*	Astragalus spp.	Syria, Persia, and Kurdistan.
„ æthiopica, *Welw.*	Berlinia sp.	Angola.
„ Berterii, *Guill.*	Adesmia sp.	Chili.
„ Blanchetii, *R. Br.*	Bauhinia spp.	Brazil.
„ Calliandræ, *R. Br.*	Calliandra sp.	„
„ Ingæ, *Hook. f.*	Inga sp.	Colombia.
„ Caulotreti, *Hook. f.*	Bauhinia spp.	Venezuela.
„ Pringlei, *Hemsl.**	Dalea frutescens.	North Mexico.
„ globosa, *Hemsl.*†	Bauhinia lunarioides.	„ „
„ Thurberi, *A. Gray.*	Dalea Emoryi.	Arizona.

* Syn. *Apodanthes Pringlei*, S. Wats.
† Syn. *A. globosa*, S. Wats.

Many other curious facts in parasitism have come to my knowledge in looking up the published and unpublished accounts of parasites; but I have said enough to demonstrate how much remains to be done by future investigators of these curious plants in their homes. I append a few references embracing some of the principal contributions to the literature of the subject of phanerogamous branch- or stem-parasites, as distinguished from root-parasites:—

Harley, John, M.D. "On the Parasitism of the Mistletoe." Transactions of this Society, xxiv. (1863) pp. 175–196.

Bull, Henry, M.D. "The Mistletoe in Herefordshire." Seemann's Journal of Botany, 1864, pp. 361–385.

Scott, John. "The Germination and Attachment of the Loranthaceæ." Journal of the Agricultural and Horticultural Society of India, ii. (1871) pp. 257–296. Repeated in part, with comments, in the 'Botanische Zeitung,' 1874, pp. 129 and 145.

Solms, H. Graf zu. *Pilostyles Haussknechtii*, in the 'Botanische Zeitung,' 1874, pp. 49 and 65, with a plate.

Solms, H. Graf zu. Rafflesiaceæ, in Engler and Prantl's 'Die natürlichen Pflanzenfamilien,' Theil 3, Abtheilung 1 (1889); and Martius's 'Flora Brasiliensis,' iv. pars 2.

Engler, A. Loranthaceæ, in Engler and Prantl's work, as cited above.

Robinson, B. L. "Two undescribed Species of *Apodanthes*." The 'Botanical Gazette' (Coulter's), xvi. (1891) p. 82, with a plate. Here referred to *Pilostyles*.

A General View of the Genus CUPRESSUS. By Dr. MAXWELL T. MASTERS, F.R.S., F.L.S., Corresponding Member of the Institute of France.

[Read 7th March, 1895.]

IN previous communications to the Society I have endeavoured to give a summary account of the general morphology of the order Coniferæ, so far as that is likely to be serviceable for purposes of classification. I have also given incidental notes concerning the structure and minute anatomy of several of the species *.

In this way the history and general characteristics of the genus *Cupressus* amongst others are briefly outlined in a paper read before the Society in December 1892 †. In the present contribution I propose to pass in review the species of this genus. Those that are well known and clearly defined in recent monographs are passed over with the mere mention. Fuller details are given concerning those whose history, diagnosis, and synonymy are obscure and involved.

Reference is made to the literature of each species under its proper heading, work in this direction having been much facilitated by the publication of the 'Index Kewensis.'

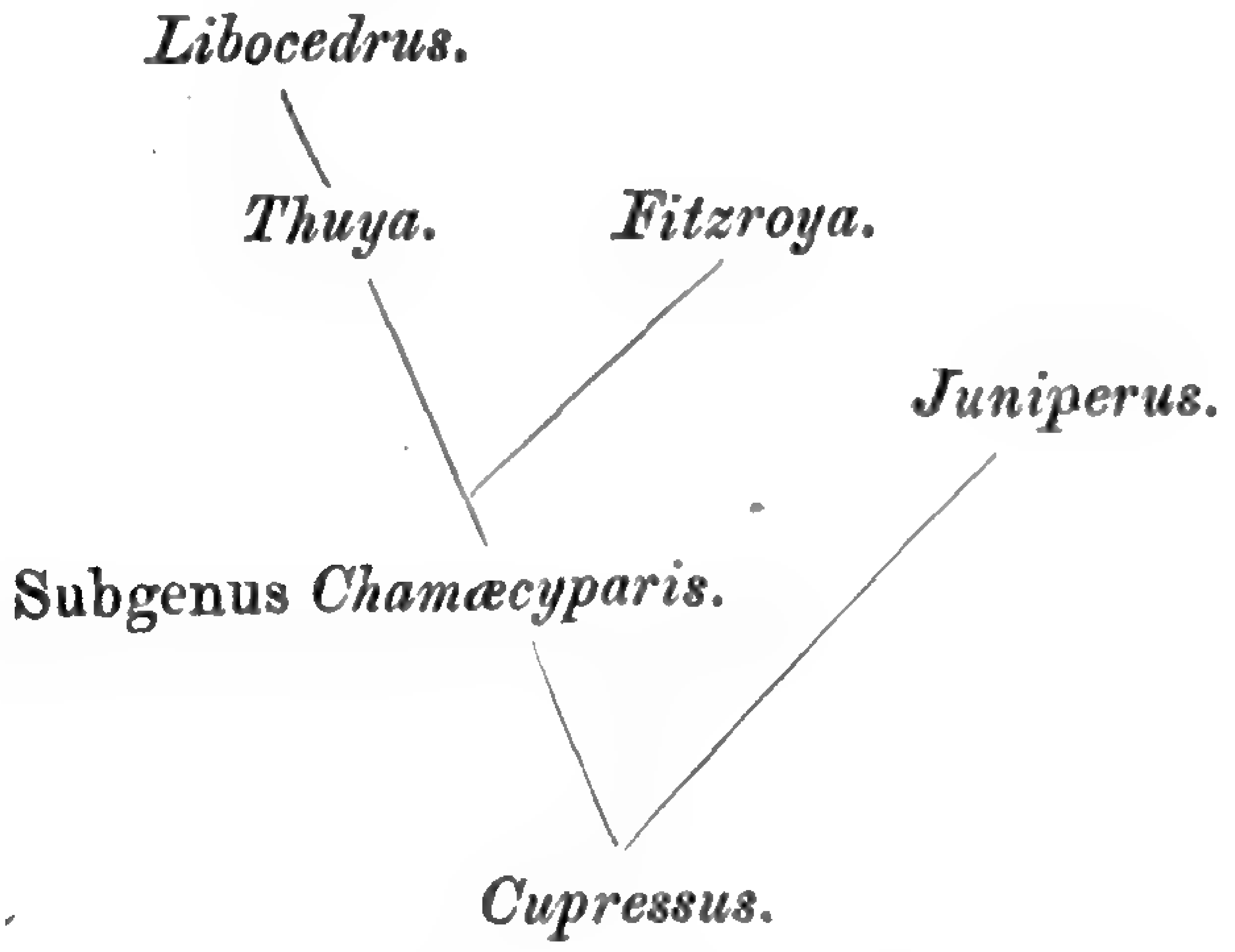
The examination of the species has been made in the herbaria at Kew, in the Natural History Museum, and in the Museum at Paris. I am also indebted to the kindness of M. Poisson of Paris, Prof. Suringar of Leyden, and Dr. Urban of Berlin, for information on various specimens in the collections under their charge. Living specimens have been studied at Kew and elsewhere, and a large number have been furnished me from British, and especially from South European gardens. The Conifer Conference held under the auspices of the Royal Horticultural Society at Chiswick, in 1891, yielded numerous illustrations, and for others I am indebted to Mr. Moore of Glasnevin, Prof. Balfour of Edinburgh, Mr. Acton, the Marchese Hanbury of La Mortola, M. Maurice de Vilmorin of Paris, Prof. Henriques of Coimbra, and specially to M. Naudin of Antibes.

Characters.—The genus *Cupressus* is a well-marked one, easily recognizable among its allies by the scales of the cone, which form

* Journal of the Linnean Society, vol. xxvi. (1889).

† Ibid. vol. xxx. (1893).

a peltate expansion at the free end. All the developed scales of the cone are fertile, and each bears in its axil either numerous seeds or only two or three, as in the subgenus *Chamæcyparis.* The genus *Thuya,* which is the nearest ally and which has similar foliage, differs in the form of the cone-scales. The cones of *Thuya* are usually oblong, and the scales are also oblong, sometimes clavately thickened at the end but never peltate, and only certain of them are fertile. If the two genera had not been so long established and so generally adopted, it might have been well to have included them in one genus, together with *Libocedrus,* as in all probability all of these have diverged from a common stock. The confusion this would entail in practice would, however, be so great as to outweigh any advantage that would accrue from such an arrangement, theoretically preferable though it might be. The following scheme may serve to represent the near relationships of *Cupressus* :—



Although the generic characters are well-marked, the case is far otherwise in regard to the species. These are few in number, but so variable that it is difficult to find characters, or to draw up a description that shall apply to the individual plant in all cases.

Moreover, each individual plant is polymorphic, that is, it assumes different appearances at different periods of its growth (see fig. 1, p. 314). These "stages of growth" are usually transitory and their existence brief, but, occasionally, their duration is prolonged and they become more or less persistent. If the whole or the greater part of the plant be in the same stage of growth at the same time, the appearance is so different from that

characteristic of the plant, at some other period, that it is not to be wondered at that botanists, before they were cognizant of the actual history of the plant, considered these temporary stages of growth to be the marks of a distinct genus. The so-called genus

Fig. 1.

Young plant of *Cupressus*, showing primordial and, at the tip of the left-hand shoot, adult foliage.

Retinospora, for instance, was founded on plants exhibiting the characteristics of certain stages of growth of a few species of *Cupressus* of the section *Chamæcyparis*, or of species of *Juniperus*

and *Thuya.* This is proved by the existence, sometimes on the same tree, of intermediate forms, by the presence of cones characteristic of the species on the branches exhibiting various phases of growth, and by the fact that seedling plants as they grow into the adult condition are found to present, on the same plant, all those foliar characteristics which have been relied on to discriminate the so-called " species " of *Retinospora.*

Although I do not concur in all the conclusions mentioned in the following passage from M. Carrière's 'Traité,' yet I cite it to show how extremely variable these plants are, and what impression that variability has made in the mind of a good observer in the habit of watching the development of these plants from the seedling stage upwards :—" C'est ainsi que le type des *Cupressus Lusitanica*, *Lambertiana*, *Goweniana* et *Knightii*, très-différents, finissent, par la suite des semis qu'on fait de leurs graines, par se confondre tellement qu'il devient tout-à-fait impossible de rapporter les individus au type dont ils sortent. Ainsi du *C. Goweniana* il est sorti des plantes qui se confondent avec les *C. Hartwegii* et *Lambertiana*, qui sont vigoureux, odorants, à branches distantes, étalées, etc., etc. Du *C. Knightii* il est sorti des individus qui se confondent tout-à-fait avec ceux qui proviennent du *C. Lusitanica.* Mais un fait curieux et que je dois signaler est celui-ci : sur un pied de *C. Goweniana*, dont les strobiles étaient sphériques et très-réguliers, il y avait, soit sur les mêmes branches, soit sur les branches particulières, des strobiles sphériques et d'autres très-allongés."—*Traité Général des Conifères*, par E. A. Carrière, p. 173 (1867).

Habit and ramification.—In attempting to distinguish the species, recourse must be had to the mature condition of the tree and to the form and disposition of the permanent foliage. The outline of the herbaceous shoots (called " turiones " by some writers) *, and their method and degree of ramification supply suggestive indications. These herbaceous shoots or branch-systems, both in this genus and in *Thuya*, would repay careful comparative study †. Frequently they have but a limited duration, they shrivel, turn brown, and are cast off all in one piece, as a

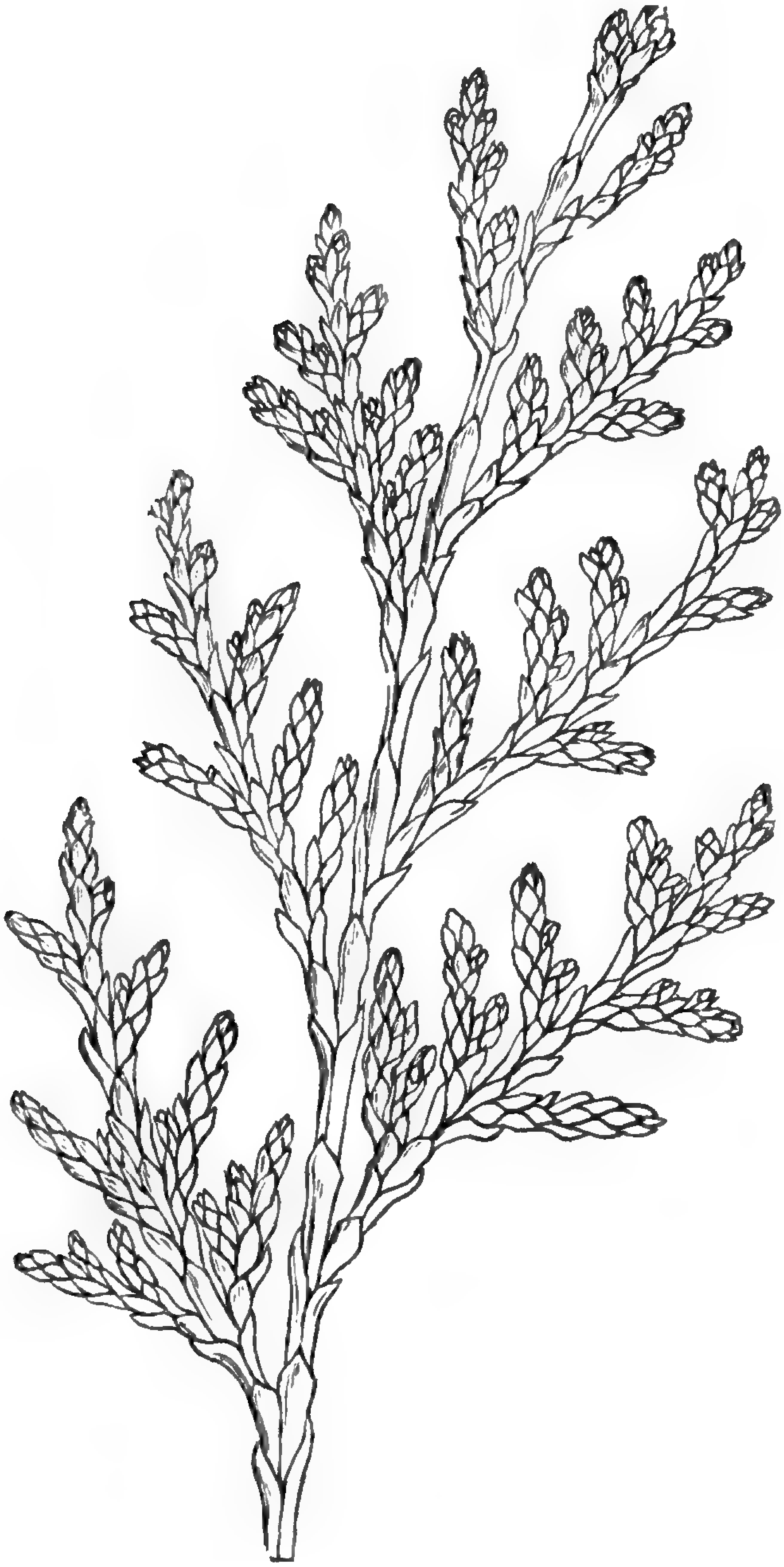
* " Turiones, habitu conformes, experientia dissimiles. Nonnulli persistendo fiunt rami ; perplurimi discedendo frondes proprie nuncupari possunt, uti folia simul et fructificationes ferentes."—L'Héritier.

† See Sachs's Text-book, ed. Vines (1882), p. 209, also p. 509.

compound leaf would be, by the process known as "cladoptosis." But in this case the individual leaves are not articulated and do not fall off.

In contour the herbaceous shoots vary from semicircular, fan-

Fig. 2.



Cupressus Lawsoniana var.—Branch system; ramification in one plane, branches bi-tripinnately divided, secondary divisions unbranched at the base.

shaped, oblong and lanceolate to linear. Their surface is flat, convex, as in *C. Nootkatensis*; scoop-like or concave in some forms of *C. Lawsoniana*. In direction they spread horizontally or at an angle, generally upwards, sometimes vertically, at other times downwards, as in the pendulous varieties.

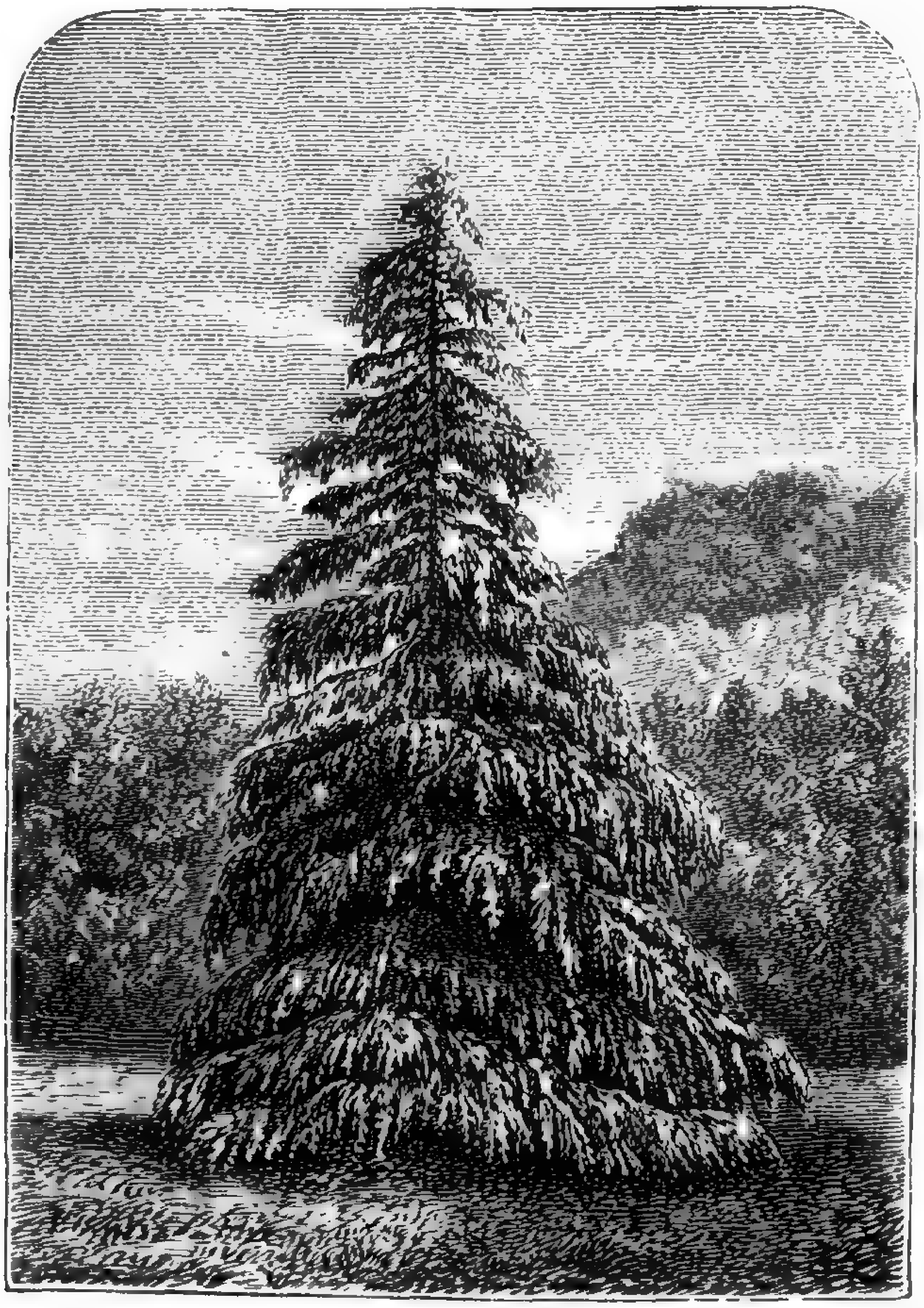
The branching is all in one plane as in the section *Chamæcyparis*, or the branchlets are in two planes and more or less decussate. The ultimate branchlets are densely crowded when a shoot is produced in the axil of each lateral leaf, or they are "remote," as when a shoot is formed in the axil of only a few of the leaves, the remainder being destitute of buds. The shoots of the last order are more or less 4-cornered or rounded; they are all nearly of the same length, from the base to within a short distance of the apex of the axis from which they proceed (see figure of *C. Benthami* var. *Knightiana*, at p. 341), or they are manifestly unequal in length, some being much shorter than others. In some instances, as also in various species of *Thuya*, no branchlets are produced on one side of the shoot near the base. The branch-system becomes thus oblique at the base and often more or less falcate in outline. Space is thus left for the more free development of the adjoining shoot, as in the case of branchlets of the lime, elm, and other plants bearing alternate and oblique leaves. This mode of branching is shown in the annexed figure (fig. 2).

The general appearance or "habit" of the tree depends very much on the arrangement and direction of the branches as just described; but habit is of little value for differential purposes, as each species subjected to the same conditions may produce similar variations in habit*. Many of them have pendulous branches; in some certain of the shoots, "leaders," "extension shoots" as they are called, grow more rapidly than others, the leaves are more deeply concrescent and at wider distances apart. In other cases this disproportionate growth is less observable, the shoots are more nearly of the same length, and a compact rounded form is the result. The ordinary form of *Cupressus Lawsoniana* has, like the *Deodar*, long slender terminal shoots gracefully bending over at the tip; whilst other forms of the

* For details concerning the ramification of the Cupressineæ, see Journ. Linn. Soc. xxvii. p. 286.

same Cypress develop in the shape of little globes of foliage, with no one shoot more prominent than another.

Fig. 3.

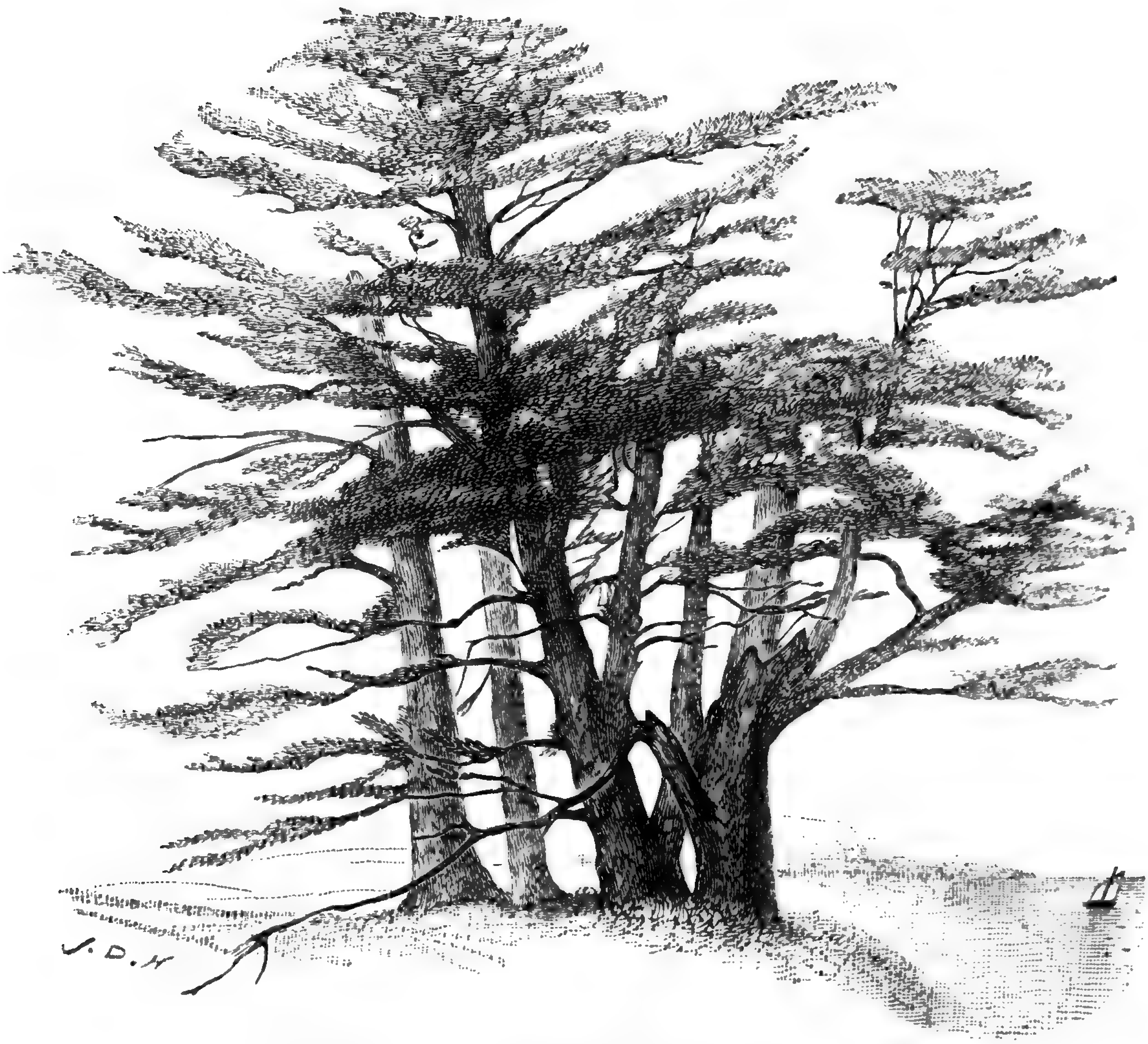


Cupressus Lawsoniana, with pendulous branches.

Another noteworthy feature is the tendency to "fastigiation," or an upward direction of the primary branches at an acute angle. This eventually results in the production of a shrub or tree of pyramidal, flame-shaped, or columnar habit, differences arising from the relative length of stem and branches. This tendency is, of course, not peculiar to Cypresses, but it is so frequent in them that the Common Cypress, *C. sempervirens*, is rarely seen in any other shape than that of a pyramidal tree. Similar forms occur in the case of *C. macrocarpa*, which in the wild state has spreading branches as illustrated by Sir Joseph Hooker's sketch (fig. 4), and *C. Lawsoniana*, the garden form of which, known as "erecta-viridis," is especially remarkable from this point of view (fig. 5, p. 320).

The differences in the mode of ramification have been relied on to furnish distinctions not only between species but between genera. Thus, the species of the section *Chamæcyparis*, the

Fig. 4.

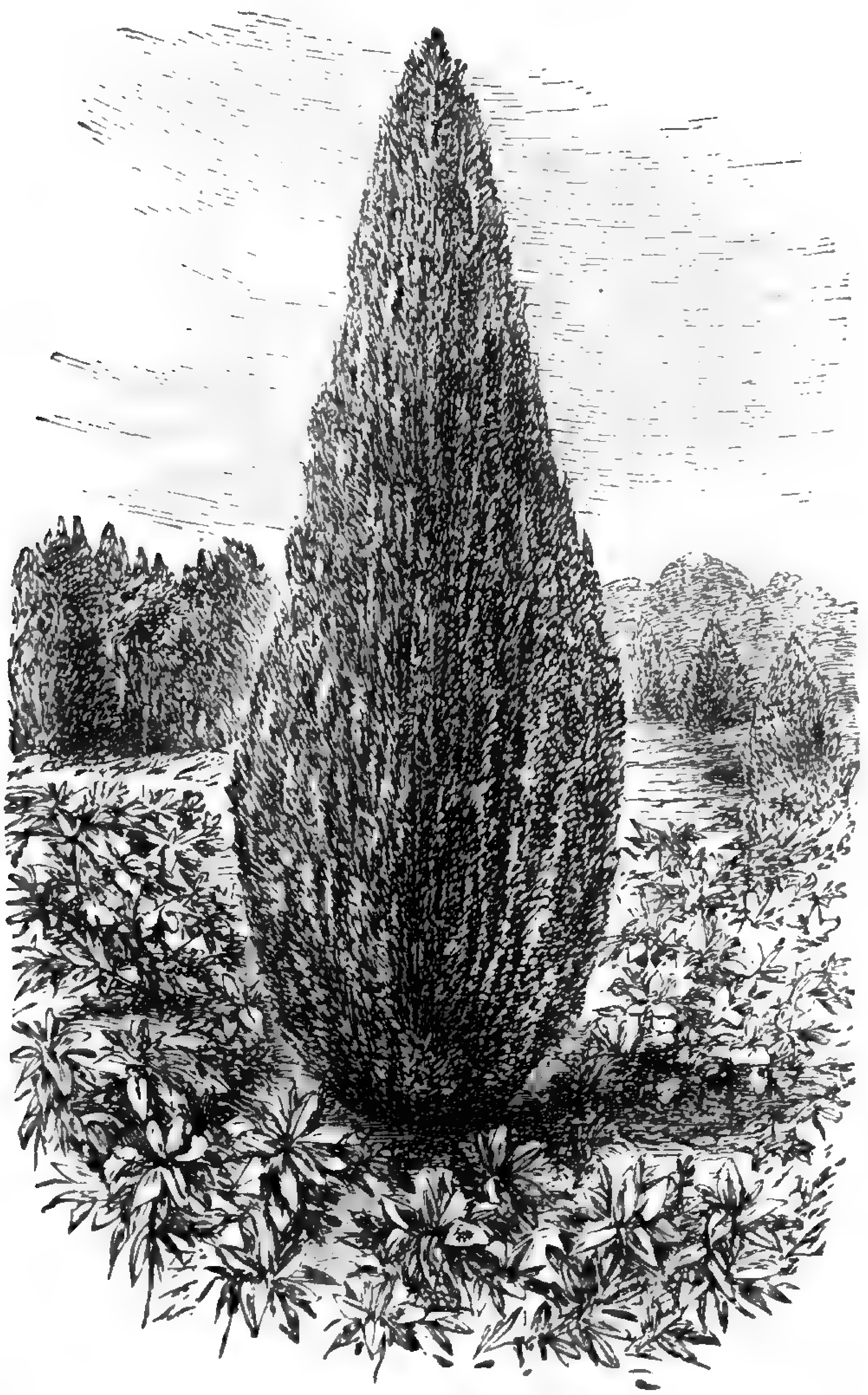


Cupressus macrocarpa.—Form with spreading branches; from an original sketch made in California by Sir Joseph Hooker.

branchlets of which are mostly in one plane, have been called flat Cypresses, and generically distinguished from true Cypresses, in which the branching of the ultimate shoots is four-ranked. But these distinctions are not constant, as a flat-branched *Chamæcyparis* with dimorphic leaves sometimes produces four-sided shoots, which branch in a decussate manner, and which

bear leaves uniform in shape, like those of a true Cypress. An illustration of this may be cited in the case of *Cupressus obtusa* var. *lycopodioides*, commonly called *Retinospora lycopodioides* in

Fig. 5.



Cupressus Lawsoniana var. *erecta-viridis*, with fastigiate branches.

gardens, whilst in the neighbouring genus *Thuya Bodmeri*, hort., furnishes a similar example.

Foliage.—The leaves of Cypresses are mostly four-ranked, tetrastichous, rarely, and only temporarily, tristichous, as in the seedling state. Sometimes all the leaves of the same order are uniform in shape; at other times, as in the section *Chamæcyparis*, the antero-posterior or facial leaves are flattened against the axis, whilst the lateral ones are more or less conduplicate.

In those species in which the leaves are uniform, the ultimate shoots are more or less distinctly four-cornered, and the

branching is decussate or in two planes, branchlets being produced alike from the axils of the median and from those of the lateral leaves. Where the lateral leaves are compressed, the branching is really or apparently in one plane, no branches as a rule proceeding from the axils of the facial leaves.

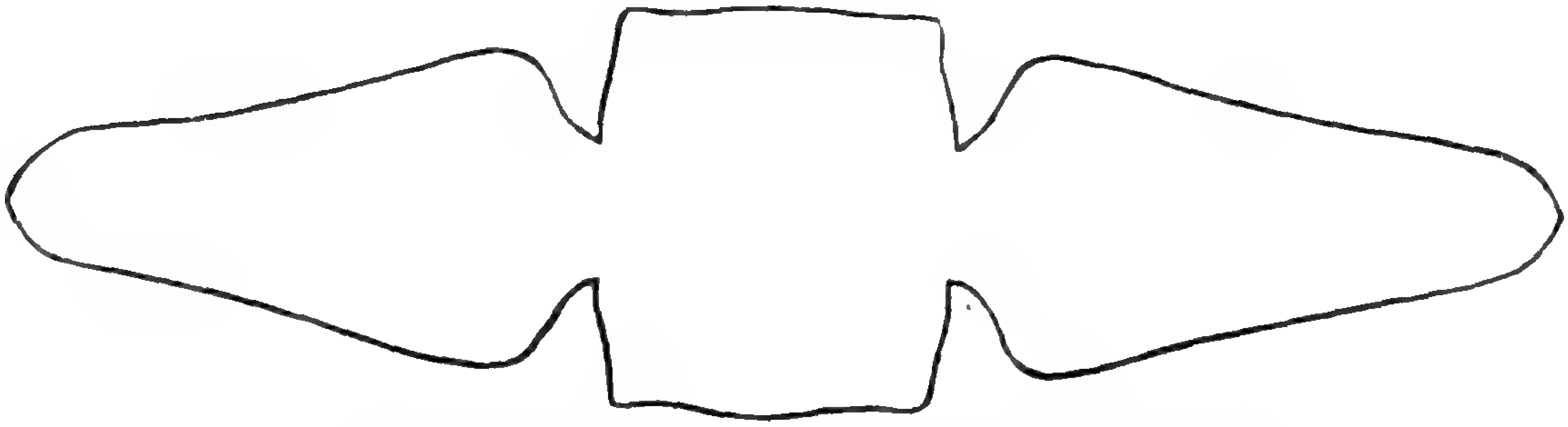
The foliage of a *Chamæcyparis* (*Retinospora*, hort.), like that of a *Thuya*, is thus often more complex than that of *Cupressus* proper. A species of the section *Chamæcyparis* has generally primordial, intermediate, and adult leaves; and, as has been stated, these sometimes all occur on different branches of the same tree at the same time, or one form of foliage may, temporarily at least, clothe the bush to the total or approximate exclusion of the others. Speaking generally, true Cypresses have but two forms of foliage, the primordial and the adult. The adult leaves correspond in general appearance to the intermediate leaves of *Chamæcyparis*. This raises a question whether the species of the section *Chamæcyparis* may not be higher developments of the Cupressineous type, for whilst a *Chamæcyparis* may revert (so far as its foliar characters are concerned) to a *Cupressus*, we do not find a true *Cupressus* assuming the adult foliage of a *Chamæcyparis*. The internal structure of the leaves of a *Chamæcyparis* is also more differentiated than in the true *Cupressus*.

That a physiological difference between the various kinds of foliage exists seems certain from the diversity of anatomical structure, and from the differences in growth. Cuttings bearing the primordial leaves "strike freely," as gardeners say, whilst cuttings taken from those branches bearing the adult form of foliage do not take root so readily, as if the vegetative energy were more or less arrested, in anticipation of the commencement of the reproductive stage. This notion, however, is not always borne out, for cones and male flowers are occasionally borne on the "squarrosa" form of *Cupressus pisifera* bearing "primordial" leaves, and also on the "plumosa" form, where the leaves are of an "intermediate" character.

It must be remembered also that the characters presented by the mode of ramification and by the foliage are not peculiar to *Cupressus*, but are present in all the Cupressineæ, which seem as if they all might have descended from a common stock closely allied to, if not the same as, that from which Lycopods and Selaginellas have been evolved.

Histology.—A section across the middle of one of the ultimate branchlets, including the lateral and sometimes, as in fig. 6, the median leaves also, often reveals the true shape of the leaf better than mere inspection of its surface. I have, therefore, added plans prepared by Mr. Worthington Smith, from camera-lucida drawings, taken from sections made by myself, or, under the direction of Mr. Houston, by the pupils of the technical laboratory of the Essex County Council.

Fig. 6.



Thuiopsis dolabrata.—Section through lateral and median leaves and axis, × 20.

The anatomical details may eventually be made use of for specific purposes. I have not ventured to do so at present, for, although I have examined the minute structure of the leaf in almost all the species, yet the leaves examined have been few in number, and they have necessarily been taken from one or two specimens only. To be of value the observations require to be repeated upon a large number of specimens in various stages of growth, and growing under diverse conditions. The anatomical structure of the leaves is less sharply differentiated than in *Pinus* or *Abies*, and is therefore not so suitable for taxonomic purposes as it is in the two genera named. In general terms the leaf-structure is as follows:—A cuticle covers the whole of the more exposed parts of the leaves, but is absent from those portions appressed to the branch and from the inner surface generally. The epidermal cells are very thick on their free walls except in the grooves and covered portions, where the epidermis is replaced by a growth of minute papules or epithelial hairs. Beneath the epidermis, on the outer or dorsal surface, is a layer of strengthening cells or hypoderm; sometimes this is continuous, at other times it is imperfect, being present only at the corners and exposed places. It usually consists of only a single

layer of cells. Within the hypoderm, we find palissade-parenchyma more or less well developed, and this is followed by layers of irregularly-shaped cells, which when more or less lengthened are horizontal, or at right-angles to the palissade-cells. It is rare that the section shows clearly the vascular bundle of the leaf, for if the section is thick it is obscure, if thin the tissues disintegrate and fall away, leaving a space; but the structure of the branchlet or axis from which the leaves proceed is usually well-defined, consisting of two, or of a ring of four, wedge-shaped (in section) masses of phloem and xylem, the latter directed towards the centre of the axis. Resin-canals are often found in the parenchyma of the leaf; but their number and relative position are not so constant as in the species of *Abies* and *Pinus*.

The structure of the flat cotyledons, of which there are two, is the same as that of the adult leaves, with the exception that there is no hypoderm. The vascular cylinder of the cotyledon has a well-marked endodermal layer, and an undivided vascular bundle. The stomata are mostly on the upper surface, next the axis.

The arrangement, size, and form of the cones offer good characters in many instances, but the large amount of inherent variability which these trees possess must never be lost sight of by the systematist. A similar remark applies to the form of the male catkins. In fact no one character can be relied on to determine a species of *Cupressus*, and the inferences to be drawn from the aggregate or sum of available characteristics require always to be carefully controlled by a consideration of the variation incidental to the growth of each individual plant, as well as of that peculiar to the species and constituting a variety.

How far these variable characters are physiological or the result of adaptation, and how far phylogenetic, it is impossible to say with accuracy. The difficulty is enhanced by the fact that in the earliest representatives of the genus with which we are acquainted the same variations existed. (See Renault, 'Cours de Botanique Fossile: Cupressineæ,' 1885, p. 121; J. Starkie Gardner, 'Mon. British Eocene Flora,' vol. ii. part 2, tab. 19.)

The anatomical structure of the cone-scale shows very distinctly its double nature: the vascular system of the bract and that of the scale being well developed, the latter having an inverse orientation of its elements. A vertical section of the axis shows that the vascular bundle for the bract, and that for the cone-scale are given off separately and independently. It is

difficult to reconcile these facts with Sachs's statement that there is no seminiferous scale * in the Cupressineæ.

Distribution.—Of some of the species the native locality still remains uncertain: thus the origin of *Cupressus lusitanica*, the largest and oldest trees of which exist in Portugal, but which are not considered to be true natives of that country, is not known. The habitat of the form known as *C. torulosa* var. *Corneyana*, is equally unknown. The Common Cypress in its horizontal form is only known wild on the mountains of Crete and Cyprus, and where the now commonly cultivated pyramidal form first appeared is not recorded.

Cypresses are found in the Palæarctic, Indo-Chinese, and Nearctic regions, and extend from the Eastern part of the Mediterranean basin through the Levant, Persia, and Afghanistan to the Himalayas, but mostly as cultivated trees. The Indian form of *C. sempervirens* (*Whitleyana*) is probably a native in W. Himalaya. *C. torulosa* is also wild in the Western Himalaya. *C. funebris* is cultivated in Tibet and Sikkim, but has recently been discovered wild in the mountains of Ichang.

In Japan two species of the subgenus *Chamæcyparis*, with numerous varieties, exist, *Cupressus pisifera* and *C. obtusa.*

In North-west America near the coast are also two species of the section *Chamæcyparis, Cupressus nootkatensis* and *C. Lawsoniana*; whilst in California and the mountains of Mexico and Guatemala there are several species, some, such as *C. macrocarpa*, being found on the Californian coast within a very restricted area. On the opposite side of the Continent, *C. Thyoides* extends from north to south.

Some of the insular forms are worthy of note as offering variation from the type growing on the mainland (see subsequent remarks on the Farallones Cypress, and on *C. guadeloupensis*, both apparently forms of *C. macrocarpa*).

The dry climate of Arizona seems also to have induced some modification in the type of *C. Benthami*, which variation Prof. Greene considers to be of specific value and calls in consequence *C. arizonica.*

In geological distribution they have been found in Pliocene and Miocene formations, but not at an earlier period than the Eocene.

* Sachs *ex* Goebel, 'Outlines of Classification and Special Morphology,' ed. Garnsey and Balfour, Oxford (1887), p. 329.

CUPRESSUS.

Linn. Gen. 1079 *ex* Tournefort, Instit. 358; Jussieu, Gen. 413; Richard, Conif. p. 142, t. 9; Endlicher, Synops. p. 55; Spach, Hist. Nat. Vég. Phan. xi. p. 323; Carrière, Traité, p. 114; Gordon, Pinetum, p. 56; Henk. et Hochst. Nadelholz, p. 230; Parlatore in DC. Prod. xvi. II. p. 467; Benth. et Hook. Gen. Plant. iii. 427; Koch, Dendrologie, ii. II. 145; Engelmann in Watson, Botany of California, ii. 113 (1880); Kent in Veitch, Manual, 225; Eichler in Engler u. Prantl, Die natürlichen Pflanzenfamilien (1889), ii. Teil, 1 Abteilung, p. 99; Beissner, Handbuch der Nadelholzkunde (1891), p. 99; Baillon, Hist. des Plantes (Conifères) (1892), p. 34.

Subgenus Eucupressus.

Strobili secundo anno maturescentes. Squamæ peltatæ lignosæ. Semina sub quâvis squamâ fere plurima.—Ramuli ultimi tetrastichi vel distichi. Folia plerumque homomorpha.

1. C. sempervirens, *Linn. Sp. Pl.* 1422, α et β (1753).

Arbor seu frutex coma effusa vel fastigiata densissime ramulosa; ramis teretibus fuscis vel rubris; foliis ramealibus dissitis longe concrescentibus late ovatis vel ovato-oblongis obtusis abrupte mucronatis, mucrone appresso vel patente; ramis herbaceis ovato- vel oblongo-lanceolatis raro suborbicularibus, planiusculis horizontalibus seu ascendentibus surde viridibus seu cinerascentibus, subregulariter distiche vel tetrastiche bi-tripinnatim ramulosis, ramulis ultimis strictis subæqualibus gracilibus pene 4-angulatis; foliis ultimis arcte imbricatis appressis parvis 1–2 mill. long., facialibus rhomboideis seu oblongo-rhomboideis obtusiusculis dorso convexiusculis, glandulâ impressâ notatis; amentis masculis in apices ramulorum solitariis terminalibus oblongis obtusis 2–3 mill. long. aurantiacis; squamis antheriferis suborbicularibus; strobilis aggregatis vel raro solitariis pedunculatis raro subsessilibus, magnitudine et formâ magnopere variantibus, subglobosis, vel oblongis obtusis, squamis 8–14 obscure 5-angulatis, dorso planiusculis, pyramidato-umbonatis vel umbilicatis, rugulosis seu leviusculis nitidis fusco-castaneis vel cinereis, bracteâ ad apicem liberâ mucronis instar nonnunquam obtusiuscula foliaceâ.

Cotyledones 2–3 patentia 10–15 mill. long. linearia-obtusa. Foliorum primordialium verticillus cotyledonibus arcte approxi-

matus. Folia primaria patentia linearia acuta basi concrescentia cotyledonibus dimidio breviora.

"Ubique culta et inde loci ubi spontanea crescit sæpe incerti" (*Boissier*). Spontanea videtur in montibus Sphacioticis Cretæ, alt. 2000–4000 ped., *Heldreich* !, *Raulin* 745 in herb. Paris ! ; in montibus Cypri silvas formans, *Sintenis* et *Rigo* 506 forma patens !

Per totam Mediterraneam culta. In herbariis exstant specimina in locis hic memoratis :—Hispania, *Porta et Rego* ! *Boissier* ! *et alii* ; Lusitania, Dalmatia, *Porta* ! ; Tyrolia, *Porta*, *Hausmann* ! ; Lombardia, *Silbermann* ! ; insulis Melos Armenis et Rhodus, *Bourgeau* ! ; Dardanelles, *Sintenis* !, *Ascherson* !, *Bentham* ! ; Algeria, *Gandoger* 653 !, *Gaillardot* ! ; e collibus Mersinæ Ciliciæ, *Balansa* ! ; ex Syria boreali, *Aucher Eloy* 5337 ! *Post* !, *Kotschy* 327 !, *Hayne* !, *Haussknecht* ! ; a Libano ad 3500–5000 ped., *Boissier* !, *Kotschy* 327 ! ; e Persia boreali, *Buhse* !, *Hohenacker* !, *Haussknecht* ! ; ex Arabia Petræa, *MacDonald* ? ! ; ex Afghanistan, *Griffith* 1353 ! 5001 ! 4988 ! In Ind. bor. occ. Kishtwar, *T. Thomson* ! In imp. Sinensi ad Shanghai, cult., *Maingay* 309 ! Subspontanea prope vicos. Prov. Yunnan, *Delavay* ! In Ins. Teneriffe, *Bourgeau* 425 ! In ins. Azorensibus. In hortis ad Rancaqua, Amer. merid. frigidior, *Bertero* 696 !, cult.

Adsunt etiam specimina in herbario Linneano proprio n. 1074 !, in herb. Mus. Britt. ex hortis Cliffortiano et Chelseiensi !, et in herb. Paris, ex Vaillant, forma fastigiata nec non horizontalis.

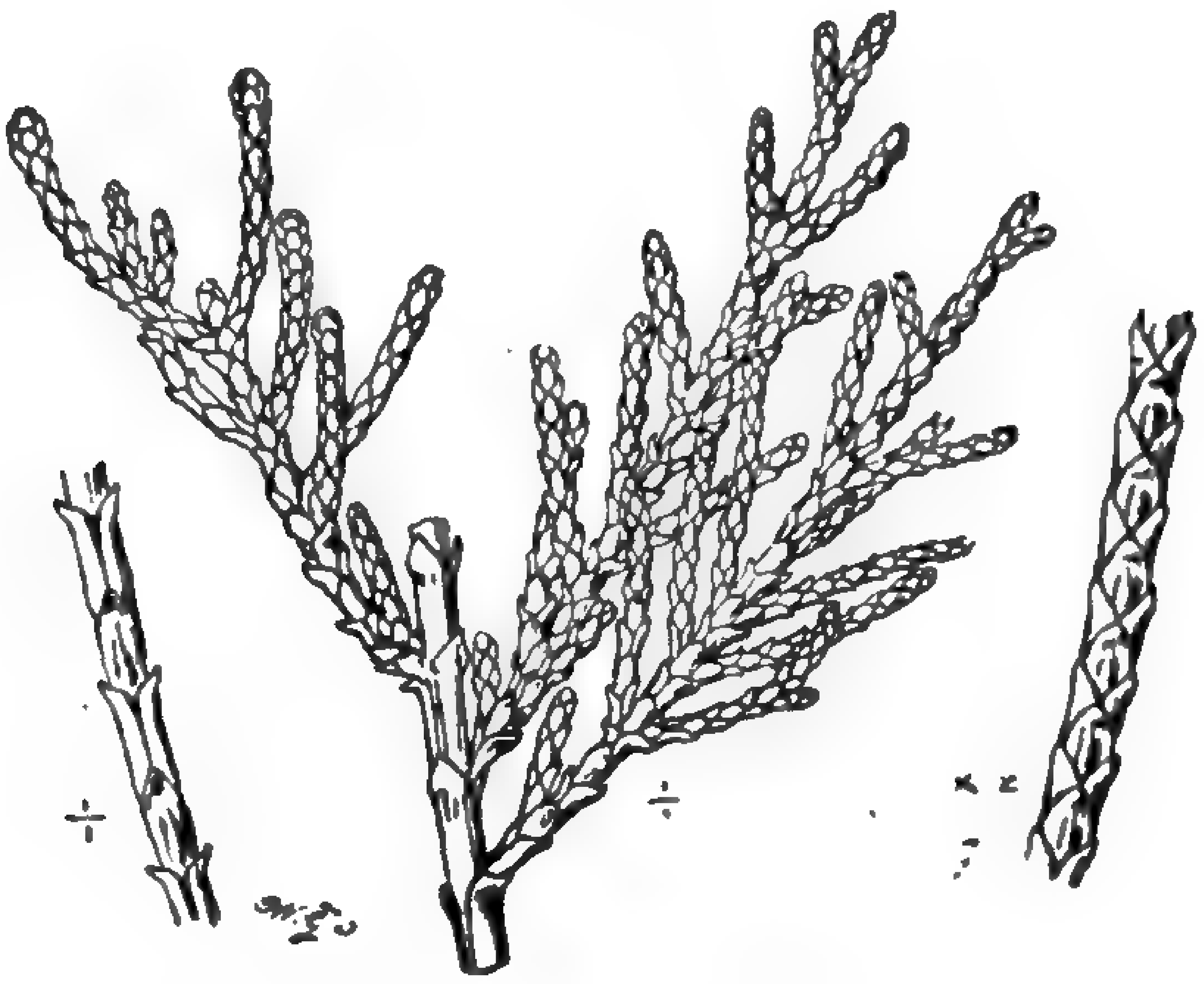
C. sempervirens, α et β, *Linn. Sp.* 1422 ; *Loiseleur in Nouv. Duhamel* (1806), t. 3, n. 1 ; *Roxburgh, Flora Indica, ed. Carey*, iii. 653, *ed. Clarke*, 678 ; *Loudon, Arboretum*, p. 2464, f. 2465, *et Encycl.* (1842), 1073, fig. 1996 ; *Forbes in Pinet. Woburn.* 181 (1839) ; *Koch, Dendrologie*, ii. II. p. 145 (1873) ; *Boissier, Flor. Orient.* v. p. 705 (1884) ; *J. D. Hooker, Flor. Brit. Ind.* v. 645 (1888) ; *Index Kewensis*, i. 671 (1893), nomen.

Juniperus oophora, *Kunze, MSS.* ? *in herb. Mus. Brit.*

Icones ad formam typicam vel ad varietates ejusdem pertinentes :—Andr. Matthioli Comm. in lib. Dioscoridis (1558), p. 90 ; Gerarde, Herball (1597) ; Pallas, Flor. Ross. t. 53 ; Gaertn. Carp. t. 91 ; Lamarck, Encycl. 787 ; Schk. Handbuch, 310 ; Watson, Dendrol. ii. 155 ; Reichenb. Flor. Germ. ii. 534 ; Nees, Gen. 4, 10 ; Duhamel, Traité (1806), t. 3, n. 1 ; Richard,

Conif. t. 9; Pinetum Woburnense, 62 (horizontalis); Spach, Suites, 90; Loudon, Arboret. viii. tab.; Ann. Sc. Nat. sér. IV. xiv. p. 13; Baillon, Adansonia, vol. i. 2; Dict. Bot. ii. (1886), 302, et Hist. des Plantes, xii. 4; Willkomm, Forstl. Flora, ed. 2, fig. 33. 5; Beissner, Handbuch, p. 101, f. 26; Compend. Flor. Ital. t. 30. f. 1.

Fig. 7.



Cupressus sempervirens.—Herbaceous branch and foliage, real size.

Cupressus mas, *Cæsalpinus de Plantis*, lib. iii. cap. 55.

C. ramos extra se spargens quæ mas Plinii, *Tournefort, Instit.* 587; *Linn. Hort. Cliffort.*

C. sempervirens, β, *Linn. Spec. Pl.* p. 1422 (1753).

C. sempervirens horizontalis, *Gordon, Pinetum*, p. 68 (1858), ed. II. p. 96 (1875); *Parlatore in DC. Prod.* xvi. II. 468; *Beissner, Handbuch* (1891), p. 102; *Kent in Veitch, Manual of the Coniferæ* (1881), p. 236; *Hansen, Pinet. Danicum, in Journ. R. Hort. Soc.* xiv. (1892) p. 287.

C. horizontalis, *Miller, Dict.* ed. VIII. n. 2 (1768), sphalmate 'horizontalibus;" specimina authentica Milleri in herbar. Mus. Brit. sunt asservata!; *Endlicher, Synops.* p. 56 (1847); *Carrière, Traité général des Conifères*, p. 115, ed. II. (1867) p. 144; *Loisel. in Nouv. Duhamel*, iii. 6; *Knight, Syn. Conif.* 19; *Targioni-Tozetti, Oss. Bot.* dec. iii. p. 54; *De Candolle, Flore Franç.* v. p. 336; *Henk. et Hochst. Nadelholz.* p. 230; *Forbes in Pinet. Woburn.* p. 185 (1839).

C. patula, *Spad. Xilog.* i. 193.

C. lugubris, *Salisbury, Prod.* 397.

C. Tournefortii, *Audib. Cat.* 1834, *ex Carrière.*

Var. FASTIGIATA; coma pyramidali, ramis ascendentibus.

Ubique culta, spontanea hucusque haud inventa nisi forte in Himalayæ montibus.

Cupressus femina, *Cæsalpinus de Plantis,* lib. iii. cap. 55, p. 134 (1583).

C. meta, in fastigium convoluta quæ femina Plinii, *Tournefort, Instit.* 587 (1700).

C. sempervirens, α, *Linn. Sp. Pl.* 1422; *Duhamel, Traité des Arbres* (1755), p. 6; *Miller, Gard. Dict.* ed. VIII. (1768) n. 2; *Loisel. in Nouveau Duhamel,* iii. t. 1 (1806?); *Richard, Conif.* t. 9; *Reichb. Ic. Flor. Germ.* xi. 534; *Veitch, Manual* (1881), 236; *Hansen in Journ. R. Hort. Soc.* xiv. (1892), p. 287.

C. sempervirens stricta, *Aiton, Hort. Kew.* ed. I. iii. 372; *Loudon, Encyclop.* f. 1996.

C. fastigiata, *DC. Flor. Franç.* v. 336; *Forbes in Pinet. Woburn.* 186 (1839); *Grisebach, Spicileg. Flor. Rumel.* ii. 354; *Endlicher, Synopsis,* 57 (1847); *Carrière, Traité,* ed. I. p. 116, ed. II. p. 146; *Willkomm, Forstl. Flor.* ed. II. (1887) 246.

C. sempervirens α. fastigiata, *Beissner, Handbuch,* 1891, 102.

C. pyramidalis, *Targ.-Toz. Oss.* ii. 53.

C. conoidea, *Spad. Xilogr.* i. 189.

C. elongata, *Salisbury, Prod.* 397.

C. ex "Moreton Bay," *hort.*

Var. SPHÆROCARPA, *Parlatore in DC. Prodr.* xvi. II. p. 469; strobilis globosis, squamis 10–12 convexis breviter mucronatis, mucrone obtusiusculo.

C. sphærocarpa, *Parlatore.*

Var. GLOBULIFERA, *Parlatore, l. c.* 469; strobilis globosis, squamis 8–10 convexis breviter mucronatis.

C. globulifera, *Parlatore.*

Hance, 8892! *in herb. Mus. Brit.*

Var. INDICA, *Parlatore, l. c.* 469; strobilis globosis, squamis sub 10 "convexis medio umbonatis et apice bracteæ acutiusculo mucronatis."

In Himal. Occident. In Nepalia et Kooloo, Prov. Lahol,

Schlagintweit 3522! (foliis oblongis acutis), in montibus usque ad limites arborum spontanea.

Cupressus sempervirens indica, *Royle MSS.*

C. Roylei, *Carr. MSS.*

C. Whitleyana, *hort.*, *ex Carr. Traité*, p. 128; *Gordon, Pinet.* p. 72.

C. Doniana, *hort.*

C. australis, *Low ex Gord. Pinet.* ed. II. 1875, 103.

Var. UMBILICATA, *Parlatore, DC. in Prodr.* xvi. II. p. 469; strobilis subglobosis, squamis 10 dorso umbilicatis ibique in medio mucronatis, mucrone lato obtusissimo brevissimo.

C. umbilicata, *Parlatore, l. c.*

Hance in Mus. Brit. 8891, *ex hort. Bot. Florentiæ.*

Var. FLAGELLIFORMIS, *Todaro*, ubi?; foliis oblongo-rhomboideis; strobilis subglobosis, squamis convexis umbonatis, mucrone latissimo foliaceo.

Præter varietates supra nominatas exstant in hortis varietates seu formæ numerosissimæ. A cl. Carrière formæ sequentes enumerantur:—*C. retrofracta, expansa, orientalis, thuiæfolia, pendula, protuberans, variegata, Bregeoni, cereiformis* (*cfr.* Revue Horticole, 1859, p. 166, c. ic.), *montrosa, contorta, Fortuselli, Fernandi.* De hisce et talibus varietatibus ita scripsit cl. Parlatore:—"Stirps ramorum et ramulorum directione, strobilorum et squamarum forma maxime ludibunda .... Observationes recentiores de strobilorum et squamarum nec non ramorum directionis variabilitate certum me fecerunt ab unica et tantum polymorpha specie omnes varietates provenire, nam in eadem arbore ramos partim fastigiatos et partim patulos, strobilos ovato-oblongos, oblongos et globosos nec non squamas nunc dorso convexas umbonatas et mucronatas nunc tantum convexas et vix aut ne vix mucronulatas, nunc rariter etiam umbilicatis mihi videre occurrit."—*Parlatore, l. c.* 469.

The common Cypress recognized from time immemorial exists under two principal forms, the one pyramidal and fastigiate, the other spreading and Cedar-like. As will be seen by reference to the synonymy, some authors have taken the fastigiate form as the type of the species and considered the horizontally branched form as a variety. Others have adopted the reverse view, whilst still others have considered the two forms to be distinct species. Against this last view may be adduced the fact that intermediate

forms are very common, even on the same tree; and individual plants are so very variable in habit and in fructification that it seems better to assume that there is but one species.

If so, it would appear from analogy with other fastigiate forms, *e. g.* in the oak, that the fastigiation is a variation from the normal spreading type. Planters have preferred the pyramidal form for their purpose, and hence that form is now much more frequently met with than the one with spreading branches. Indeed, the tree is now rarely met with in a wild state. It would be interesting to know whether the wild form found on mountains in the Levant and in the Himalayas is fastigiate or not, for, obviously, the pyramidal form would be less liable to injury from the weight of snow than that with horizontal branches, and would be in so far better adapted to its environment. Pliny says, "The Cypress grows on the white mountains of Crete. On the very summit of these elevations, from which the snows never depart, we find the Cypress growing in great abundance, a thing that is truly marvellous, seeing that in other countries it will only grow in warm localities" (Bohn's translation *). In Ecclesiasticus, Chap. XXIV. v. 15, mention is made of the Cypress and its habitat on mountains. "I am set upon hil like a Cedar in Libanus and as Cypres tree upon the mountaines of Hermon" (cited from Robert Barker's "The Bible, that is the Holy Scriptures, 1615").

In Isaiah, XLIV. 14, the "Cypress" is mentioned as a timber tree: "He heweth him down Cedars, and taketh the Cypress and the Oak." But the writer of the article "Cypress" in Smith's Dictionary of the Bible asserts his inability to assign any definite rendering to the word *tirzah*, and hence the identity of the tree intended must still be considered as uncertain.

Numerous references to the Cypress as known to Latin authors, and the uses to which it was put, are given in Duhamel's 'Traité des Arbres et Arbustes qu'on cultive en France,' to which the reader may be referred for copious and interesting details on the history of the plant; as also to the English edition of Hehn's 'Wanderings of Plants and Animals from their first home,' ed. Stallybrass.

* Pliny, lib. XVI. cap. xxxiii.:—"... summisque jugis Cretæ], unde nives numquam absunt, plurima, quod miremur: alibi non nisi in tepore proveniens, et nutricem magnopere fastidiens."

Humboldt considered the native home of the Cypress to be the mountains of Buseh west of Herat. Ritter agrees that the true home of the mountain Cypress lies to the west of the Valley of the Indus in the table-lands of Caboul and Afghanistan. "From this home the Cypress migrated westward in company with the Iranian worship of the sun. The Zends saw in the heavenward aspiring obelisk shape of the tree the image of the sacred flame . . . . and all over Iran venerable specimens of it adorned the temples of fire, the courts of the palaces and the centre of the Medo-Persian shrubberies or 'paradises.' Following the path of the oldest Assyrio-Babylonian migrations, the Cypress very early arrived in the countries of the Aramæo-Canaanite tribes, the Lebanon and the island of Cyprus, which took its name from the tree, and there too became a holy tree in which a goddess of nature was present; the same shown to us in the Troad by Virgil, who describes her ancient deserted temple with the sacred Cypress, in this case calling the deity Ceres, while in another he calls her Diana." *

With reference to the original habitat of the Cypress in Afghanistan, the testimony of Aitchison is not very strong. In his note on the Products of Western Afghanistan and of North-eastern Persia †, he tells us that the native names are *saur*, *saro*, *sarun*, *sarwi*, and *sawu*; and continues: "A few of this occur cultivated in gardens at Herat; I fancy I saw some at Meshad. The only one I have noted in my Journal is a tree to the west of the fort of Sangun." In the same author's 'Botany of the Afghan Delimitation Commission' ‡ no mention whatever is made of any *Cupressus*. Roxburgh § says "the upright variety is a native of China and of the northern mountains of India and Persia. It does not thrive on the plains of Bengal."

2. CUPRESSUS LUSITANICA, *Miller, Dict.* ed. VIII. (1768) n. 3.

Arbor comâ effusâ modo densissime, modo laxiuscule ramosâ, ramis teretibus; foliis ramealibus deltoideo-ovatis subulatis; ramis herbaceis oblongo-lanceolatis bipinnatim ramulosis confertim seu laxiuscule tetrastiche ramulosis, ramulis tetragonis

* 'The Wanderings of Plants and Animals,' by Victor Hehn; edited by J. S. Stallybrass, p. 212.

† Aitchison in Trans. Bot. Soc. Edinb. xviii. (1891) p. 51.

‡ Trans. Linn. Soc. 2nd ser. Bot. vol iii. (1887) p. 113.

§ 'Flora Indica,' ed. Clarke, p. 678.

curvatis vel strictis; foliis ultimis laxiuscule appressis, facialibus oblongis obtusiusculis nonnunquam ovato-lanceolatis acutis ad margines excisis subcarinatis planiusculis glandulosis; amentis subglobosis obscure 4-angulatis; strobilis parvis (magn. cerasi parvi), longiuscule pedicellatis subglobosis cæsiis, squamis umbonatis, umbone in processum foliaceum planiusculum acutum vel obtusum sæpius deflexum protracto.

Folia primordialia tenuissima patentia lineari-subulata (herb. Paris).

Hujusce speciei elegantissimæ locus natalis ignotus. In Lusitaniâ, Hispaniâ, aliisque regionibus calidioribus culta et ex Goâ, ut dicitur, sed dubie, allata.

In herb. Miller in Mus. Brit. asservato specimen adest sub nom. *C. lusitanicæ*, nec non alia ex hortt. Chelsea, Herrenhausen (herb. Rœmer), et ex hort. Goodwood ducis Richmond. In herb. Paris specimina adsunt in herb. Vaillant et ex hortis Monspeliensis, "la Malmaison."

In Lusitania ad Bussaco, *Henriques*!, *Winkler*!, *Shuttleworth*!; *Schulz, herb. normale* 1471!; in Hispaniâ ad Granadam, *Willkomm*!, *Shuttleworth*!, *Porta* 121!; in ins. Madeira, *Burchell* 609!, *Mandon*!; Cordoba, *Hieronymus*. In Brasiliâ, *teste Eichler*. In Italiâ ad Neapolim, *Rabenhorst*! Ex hortis Europæis, Indicis, Austro-Americanis, Capensibus, et Australiensibus, specimina numerosissima recentiora vidi.

Juniperus ex Goa, *Hermann, Hort. Lugd.-Bat. Cat.* p. 346 (1687).

Cedrus a Goa et Sabina Goensis, *Ray, Hist. Plant.* ii. pp. 1414 et 1798 (1688).

Cedrus ex Goa, *Sloane in epist. ad Raium Nor.* 11 (1684).

In herb. Sherard, Oxon. (fide comiss. Druce) exstant specimina quatuor hujusce speciei nn. 5839, 5838, 5843, et 5844, locis haud nominatis.

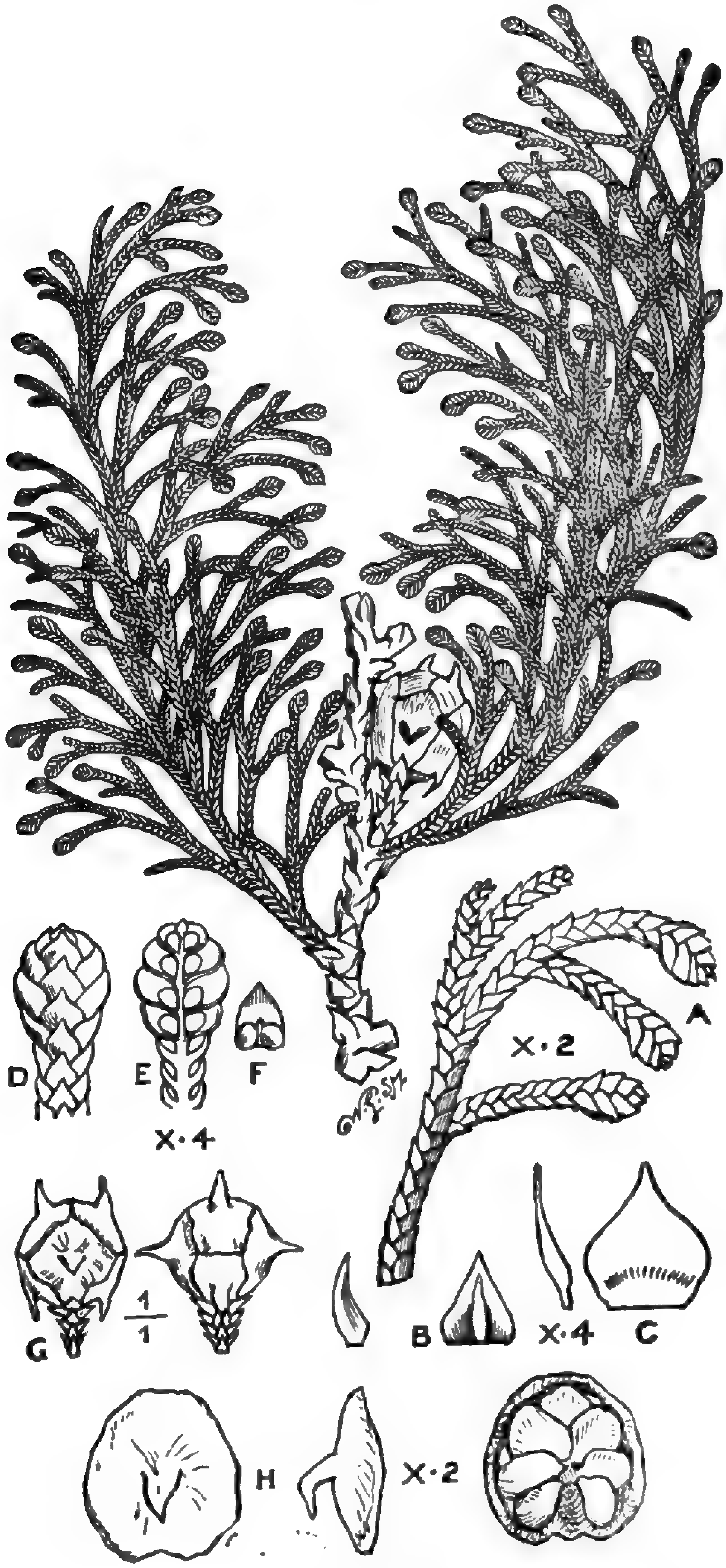
Icones:—Lambert, Pinus, ii. 49; Forbes in Pinet. Woburn. 62, sub nom. *C. lusitanicæ*; L'Héritier, Stirpes, 15, t. 18; Nouv. Duhamel, iii. 3, sub nom. *C. pendulæ*; Gard. Chron. ser. III. x. (1891), 761, sub nom. *C. glaucæ*.

C. lusitanica patula fructu minore, *Tournefort, Instit.* 587; *Loisel. in Nouv. Duhamel Arb.* i. p. 98.

C. lusitanica, *Miller, Dict.* ed. VIII.; *Willd. Sp. Pl.* (1805) iv. 511; *Lambert, Pinus* (1803), 95, t. 42; *Aiton, Hort. Kew.* ed. II.

vol. v. (1813), p. 323; *Forbes, Pinetum Woburnense*, 187 (1839); *Loudon, Encycl.* 1075, fig. 1998 (1842); *Tenore, Osserv. sopra*

Fig. 8.



Cupressus lusitanica.

alcuni Cipressi (Modena, 1853); *Carrière, Traité*, p. 119, ed. II. p. 155; *Gordon, Pinetum*, p. 63, ed. II. (1875) p. 89; *Veitch*,

Manual, 228; *Eichler in Mart. Flor. Brasil., Conif.* (1863) t. cxiii. II.; *Masters in Journ. Roy. Hort. Soc.* xvii. (1894) p. 1 (ubi arboris hujusce jucundissimæ historia est elata); *Hansen in Journ. R. Hort. Soc.* xiv. (1892) p. 285.

Cupressus glauca, *Lam. Encycl.* ii. 243 (1786–1790); *Spreng. Syst.* iii. p. 889; *Brotero, Fl. Lusit.* i. 216 (1804); *Endlicher, Synops.* 58 (1847); *Parlatore in DC. Prod.* xvi. II. 470; *Willkomm & Lange, Prod. Flor. Hispan.* (1861) i. 21; *Brandis, For. Flor.* 534; *Dalzell et Gibson, Bombay Fl. Suppl.* 83 (1861); *J. D. Hook. in Flor. Brit. Ind.* v. 645 (1890); *Masters in Gard. Chron.* ser. III. x. (1891), Dec. 26, p. 761, fig. 110; *Willkomm in Gartenflora* (March 1890); *Useful Plants of Bombay, by J. C. Lisboa, Bombay* (1886), p. 133.

An sit *C. sempervirentis* vel *C. torulosæ* varietas dubitat cl. Hookerus.

C. pendula, *L'Hérit. Stirp.* 15, t. 8 (1784); *non Thunb., nec Abel, nec Lamb.*; *Nouv. Duhamel*, tab. 2 (1806); *Aiton, Hort. Kew.* ed. I. (1789), iii. p. 373; *Persoon, Synopsis*, ii. (1807) p. 580; *C. Koch, Dendrologie*, ii. II. (1873) p. 151.

C. Uhdeana, *Gordon, Pinet.* 71, *excl. loc. fide Parlatore, sed?*; *Carrière, Traité*, p. 128.

C. sinensis, *hort.*

The following names of garden-forms are referred to this species by C. Koch, *l. c.*:—*C. cinerea, C. capensis, variegata, goensis, sinensis, sinensis glauca, sinensis pendula, Libani glauca, mexicana glauca.* Carrière also considers the following Mexican trees to belong to this species, viz., *C. Benthami, C. Uhdeana*, and *C. Lindleii*, but this identification is open to doubt.

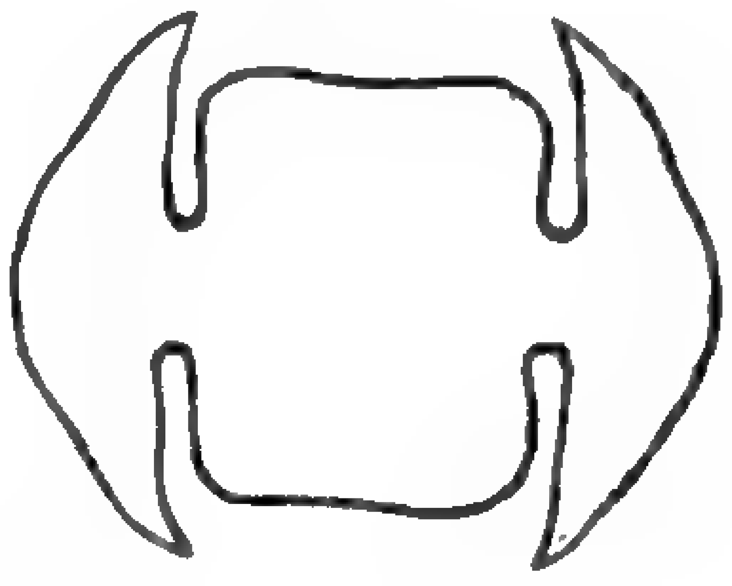
A summary of the history of this tree is given in a communication to the Royal Horticultural Society *. Although the Portuguese botanists do not consider it a native—there are no large trees known out of Portugal, and the species is not found wild in the neighbourhood of Goa,—it is possible that the Portuguese may have met with the plant in China and transferred it thence to Goa and the mother country. The tree, however, is as I am informed by Mr. Tutcher, not found in the neighbourhood of Macao.

A cross section through the adult leaves of the "Cedar of Goa" from Bussaco shows each leaf to have a semi-elliptical form, convex dorsally, more or less concave internally, and with the

* Masters in Journ. Royal Hortic. Soc. vol. xvii. (1894) p. 1.

ends of the section corresponding to the margins acutely pointed. The epiderm is thickened on the outer surface. The hypoderm is continuous and most observable at the edges. The palissade is imperfect and the parenchyma is traversed by a resin-canal. The stomata have two elliptic guard-cells.

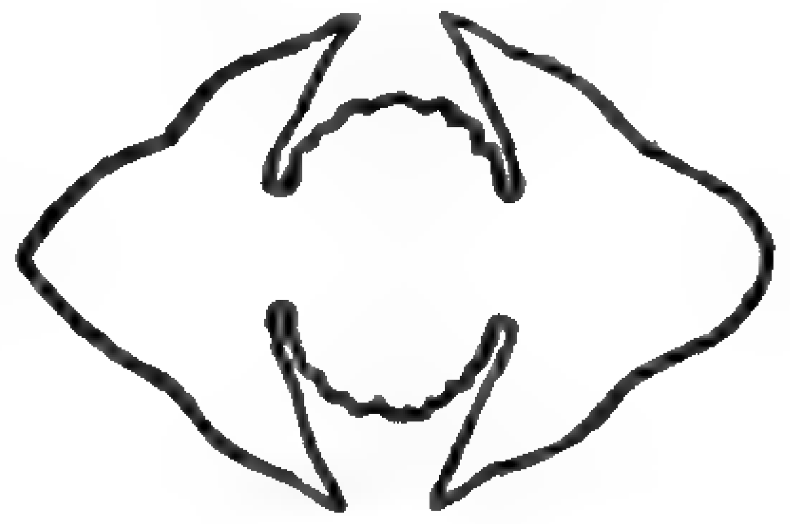
Fig. 9.



Section across the centre of two leaves of *C. lusitanica*, "Cedar of Goa."—The median leaves are cut across at the base.

Similar sections across the leaves of the plants known as *pendula* or *pendula glauca* show a similar but not identical arrangement; the dorsal surface is more keeled, and the section is in consequence more triangular in outline. Beneath the thin epiderm is a layer of discontinuous hypoderm. There are only imperfect palissade-cells or none at all, these cells being replaced by loose cellular tissue traversed near the corner by a resin-canal. On the inner surface next the axis the epiderm is papular.

Fig. 10.



Section across leaves of *C. pendula glauca*.

3. Cupressus torulosa, *D. Don, Prod. Fl. Nepal.* 55 (1825). Arbor comâ pyramidatâ, ligno-roseo; ramis assurgentibus teretibus; foliis ramealibus dissitis basi concrescentibus appressis deltoideis seu oblongis acutis; ramis herbaceis oblongo-lanceolatis planiusculis seu curvatis horizontalibus vel ascendentibus apice decurvis atro-viridibus subremote regulariter bipinnatim ramulosis, ramulis distichis remotiusculis subæqualibus vix teretibus subtetragonis, verberiformibus; foliis ultimis oblongo-rhomboideis obtusiusculis convexis glandulosis, marginibus excisis, apice parum patentibus; amentis oblongis subtetragonis, squamis antheriferis late ovatis obtusis; strobilis pluribus aggregatis raro solitariis, subsessilibus magn. cerasi, squamis 8–10 umbonatis; bracteâ cum umbone protracto concrescente apice liberâ.

In Himalayæ regionibus occidentalibus centralibus temperatis inter 4500–8500 ped., *Wallich* 6046 B ! et 9947 !, *Jameson* !, *Jacquemont* !, *Royle* !; Bhotan, *Webb* !; Simla, *Hook. f. et Thoms.* !, *Thomson* 642 !; Chamba Kulu, alt. 7000 ped., *Edgeworth* 254 !; Nynee Tal, *Strachey et Winterbottom* !; Kumaon et Gurwhal, *Duthie* !, *Capt. Gerard* ! *in herb. Mus. Brit.* !, *Falconer* !

Icones:—Griffith, Ic. Plant. Asiat. t. 372; Murray, in Pinet. Brit. 201; Loudon, Arboret. f. 2329–31; Encycl. 1076, f. 1999–2001; Lambert, Pinus, ed. II. 113.

Endlicher, Synops. 58; Dalzell et Gibson, Bombay Flor. Suppl. 83; Parlatore, in DC. Prodr. xvi. II. 469; Brandis, For. Flor. 1874, 533; Gamble, Mon. Ind. Timber, 410; Hook. Flor. Brit. Ind. v. (1888) p. 645; C. Koch, Dendrol. ii. 159; Veitch, Manual, 239; Gordon, Pinetum, ed. II. 97; Carrière, Traité, p. 117, ed. II. p. 151; Forbes in Pinet. Woburn. 189.

Cupressus Tournefortii, Tenore in Mem. Soc. Ital. Scien. Modena, t. xxv. pars 2 (1853), tab. 1 *a*, haud Audibert.

Var. CORNEYANA.

A *C. torulosa* typica teste cl. Parlatore, l. c. p. 470, differre videtur "ramis ramulisque omnino pendulis, glandulis foliorum vix conspicuis, strobilisque sæpius ovalibus haud umbonatis sed tantum apice bracteæ adnatæ libero incurvo mucronatis et super mucronem tantum glaucis." . . . . "Strobili 15–20 mill. longi, 10–14 mill. lat. Specimina culta tantum vidi ideoque de patria ejusdem speciei respondere non possum."

C. Corneyana, *Gordon ex Knight and Perry, Conif.* p. 20 (1850); *Gordon, Pinet.* ed. II. p. 80; *Carrière, Traité,* ed. I. p. 28; *Parlatore, l. c.* p. 470.

C. torulosa, Corneyana, *Carrière, Traité,* ed. II. p. 121 (1867); *Kent in Veitch, Manual,* 239.

C. funebris, *Karl Koch, Dendrologie,* ii. II. 160, *haud Endl.*

Strobilorum squamæ juventute valde umbonatæ, senescendis tamen planiusculæ obscure mucronatæ evadunt.

E Chinâ vel e Japoniâ ut existimant auctores allata, specimina indigena hucusque tamen haud offensa.

In hortis exstat varietas vegetior ramulis ultimis insigniter decurvatis cui nomen *C. torulosa majestica,* Gordon, Pinet. ed. II. 100 = *C. majestica,* Knight et Perry. A cl. Carrière varietates hortenses sequentes enumeratæ sunt:—*viridis, filiformis, Tournefortii* (Tenore non Audib.), *nana, juniperoides, microcarpa, Smithiana.*

Dr. Jameson says (Journ. Horticult. Soc. 1853, p. 312) that this species is known to the natives as 'Surroo' or 'Surin,' and near Simla, where it occurs in the vicinity of temples,

it is styled 'Deodar,' the *Cedrus Deodara* being there known as 'Keloo.'

The plant figured under this name in Paxton's Flower Garden, i. 167, f. 105, and the figure of which is repeated in the 'Flore des Serres,' viii. 192, and in the 'Garden,' is doubtless *C. macrocarpa.*

4. CUPRESSUS FUNEBRIS, *Endlicher, Synopsis Conif.* 58 (1847).

Arbor comâ effusâ; ramis horizontalibus apice pendentibus, teretibus rubris; foliis ramealibus parvis appressis suborbiculari-bus mucronatis; ramis herbaceis angustis elongatis planiusculis pendulis subæqualiter bipinnatim ramulosis elegantissimis, ramulis remotiusculis tetrastichis gracilibus subæqualibus ancipitibus seu pene 4-angulatis; foliis parvis 1–2 mill. long. deltoideis acutis ad margines sinuatis læte viridibus glandulosis; amentis ovato-oblongis subtetragonis, squamis antheriferis ovato-orbicularibus; strobilis solitariis raro aggregatis breviter pedicellatis globosis diam. circa 1 cent., squamis 8 obscure pentagonis breviter umbonatis, bracteâ cum umbone concrescente apice liberâ; seminibus orbicularibus compressis alatis.

Folia primordialia quadrifariam verticillata basi cum axe concrescentia apice liberâ patentia lineari-subulata nervo medio utrinque prominente.

China, *Sir G. Staunton* in herb. Mus. Brit.! Indigena in China meridionali-occidentali prope fluv. Yang-tse-Kiang, *Faber* 991!; Su Tchuen dist., Tchen Keoa Tin, alt. 1200 met., native name Pee Chow, *Fargies* 1158 in herb. Paris! In montibus prope Nauto, Ichang, *Henry* 1070! 1898!; *Maries*! In Chinâ alibique ad busta et tumulos plantata, *Fortune* 45!, *Champion*!, *Urquart*! Colitur etiam in Sikkim, *Hook. fil.*!; in Bootan, *Griffith* 2613, 1! 3000, 1!; Singapore, *Ridley*!

"The Weeping Thuya" or "Lignum Vitæ," *Staunton, Embassy to China* (1792), ii. 445, t. 41; *Fortune in Gard. Chron.* (1850), 228; *J. D. Hooker, Himalayan Journals*, i. 315.

Cupressus funebris, *Endl. Synops.* 58; *Gordon, Pinetum*, ed. II. 83; *Carrière, Traité*, 120, ed. II. 161; *Knight and Perry, Synops.* 19; *Veitch, Manual*, 227; *Hook. f. Flor. Brit. Ind.* v. (1890) 646; *Parlatore in DC. Prodr.* xvi. II. 471; *Brandis, For. Flor.* 534; *Gamble, Manual Indian Timbers*, 410; *Hansen in Journ. R. Hort. Soc.* xiv. (1862) p. 285.

Icones:—Planchon in Flore des Serres, vi. p. 90; Lambert,

Pinus, ed. II. p. 124, t. 66; Loudon, Arboretum. iv. 2479, f. 2332; Paxton, Flower Garden, i. 46, f. 31; Moore & Ayres, Magazine Bot. i. 276, f. 1, sub nom. *C. funebris*; Abel in Staunton Embassy, *l. c.* (1816); Loudon, *l. c.*, sub nom. *C. pendulæ*, haud Thunberg (1784) synonymiisque exclusis.

Cupressus amœna, C. Koch, in Monatschrift f. Garten u. Pflanzenkunde, i. 110 (1873), et in Dendrologie, ii. II. 164.

Fig. 11.

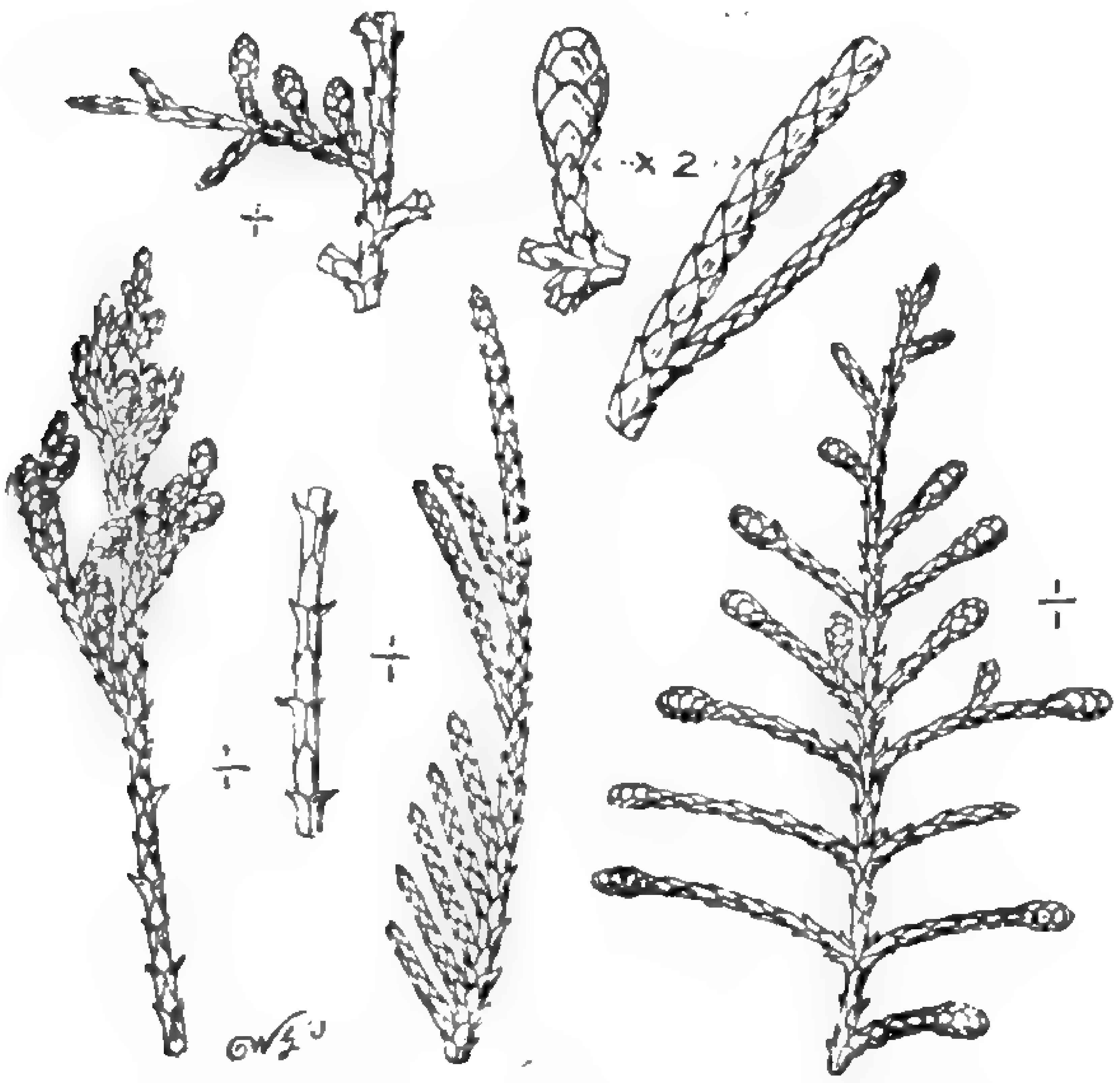
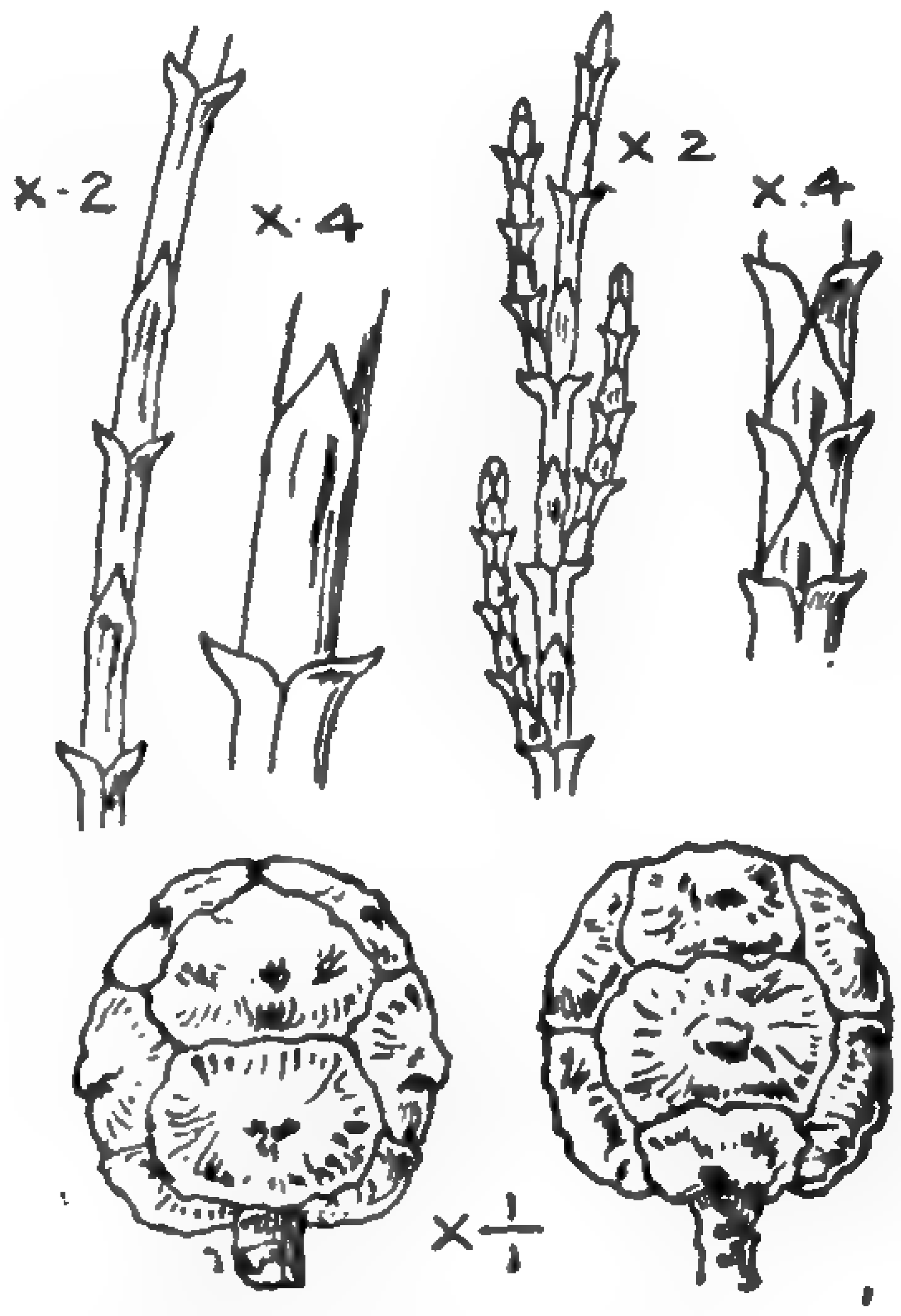


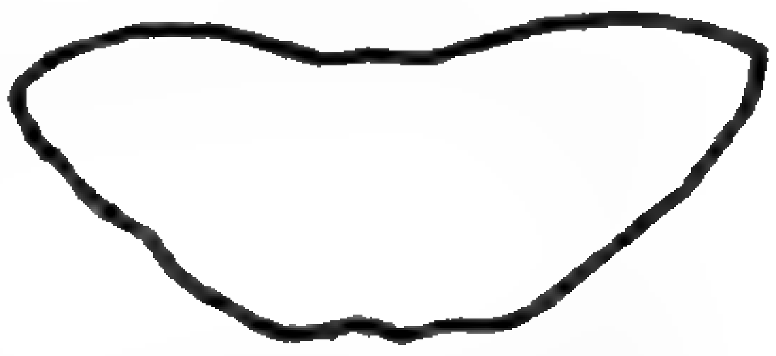
Fig. 12.



C. funebris.—Herbaceous branches, foliage, catkins, and cones, real size. Fig. 11, cultivated specimen; fig. 12, natural specimen from Ichang.

A section across the leaves of *C. funebris* shows an elliptic outline generally curved outwards, convex dorsally, concave on the opposite side, and somewhat blunted at the two ends, generally more so than in the specimen figured. The epiderm is much thickened on the distal side, but there are no hypodermal cells except at the angles. The palissade-cells are well-marked, but the endodermal layer is not developed.

Fig. 13.



Section across leaf of *C. funebris*, × 20.

5. Cupressus Benthami, *Endlicher, Synopsis Conif.* (1847) p. 59.

Arbor coma effusa laxiuscule ramosa, ramis teretibus rubris; foliis ramealibus homomorphis oblongis vel deltoideis abrupte subulato-acuminatis acumine laxe appresso; ramis herbaceis foliis undique tectis ambitu late oblongis planiusculis ascendentibus læte viridibus subregulariter bipinnatim ramulosis; ramulis

distichis raro tetrastichis decussatis, subtetragonis; foliis ultimis carnosulis 1 mill. et ultra long. facialibus deltoideis vel deltoideo-oblongis acutis vel obtusiusculis dorso convexis glandulâ notatis vel eglandulosis ad margines parum sinuatis; amentis masculis 4 mill. long., oblongis obtusis subtetragonis; squamis antheriferis suborbicularibus; strobilis aggregatis raro dissitis breve pedunculatis, 1–1½ cent. diam. globosis, rufescenti-fuscis, squamis rugulosis planiusculis umbonatis glaucis, bracteæ concrescentis apice libera subulato-mucronata subfoliacea.

Habitat in Mexici regione montana frigida, spec. authent. *Hartweg* n. 434! partim!, 437!; *Ruiz et Pavon* in herb. Mus. Brit.; *Schmidt* 971; *Liebmann*! In Orizaba ad Cocolapan, *Bourgeau* nn. 245, 254, et 3258!; Sierra Madre, *Seemann* 2000!, *Palmer* 1293!; Nevada de Toluca, 9000 ped., *Pringle* 4253, *Uhde* 69!; *Moricand* 1169!; *Schaffner*!; *Parry et Palmer* 1294!; *W. Murray*!; *Hahn* 362, 376!; *Virlet d'Aout* 862; *Berlandier*! ? In Nov. Mexico, *Fendler* 834! In Guatemalæ montibus, *Lehmann* 1591!; *Donnell Smith* 1891 et 3157!

Parlatore in DC. Prodr. xvi. II. p. 472; Hemsley in Biol. Centr.-Amer. vol. iii. 1882–86, p. 183.

C. sempervirens mexicana, *Pavon in herb. Banks*!

C. thurifera, *Schlecht. in Linnæa*, xii. 423; *Benth. Plant. Hartweg* (1840), p. 57.

C. Coulteri, *Forbes in Pinet. Woburn.* (1839) p. 190, e seminibus in herb. Coulter per quindecim annos servatis producta. Nomen forsan rectius delendum propter descriptionem nimis incompletam plantæ juvenilis. ? *C. Coulteri*, hort. Glasnevin!

C. Uhdeana, *Gordon in herb.*!

? C. Ehrenbergii, *Kunze in Linnæa*, xx. 16.

C. Karwinskyana, *Regel in Gartenflora*, 1857, p. 346, *teste Parlatore.*

C. excelsa, *Gordon, MSS.* *C. kewensis*, hort.

Var. LINDLEII; ramulis ultimis longitudine subæqualibus, regulariter dispositis, curvatis tetragonis, foliis rhomboideo-lanceolatis; strobilis parvis globosis, squamis mucronatis.

In Mexico inter Anganguio et Tlalpuxahua, *Hartweg* 437! spec. typicum; Barranca au dessus de Tacuhaya, *Bourgeau* 245!; *Parry et Palmer* 848!; *J. Ball*!

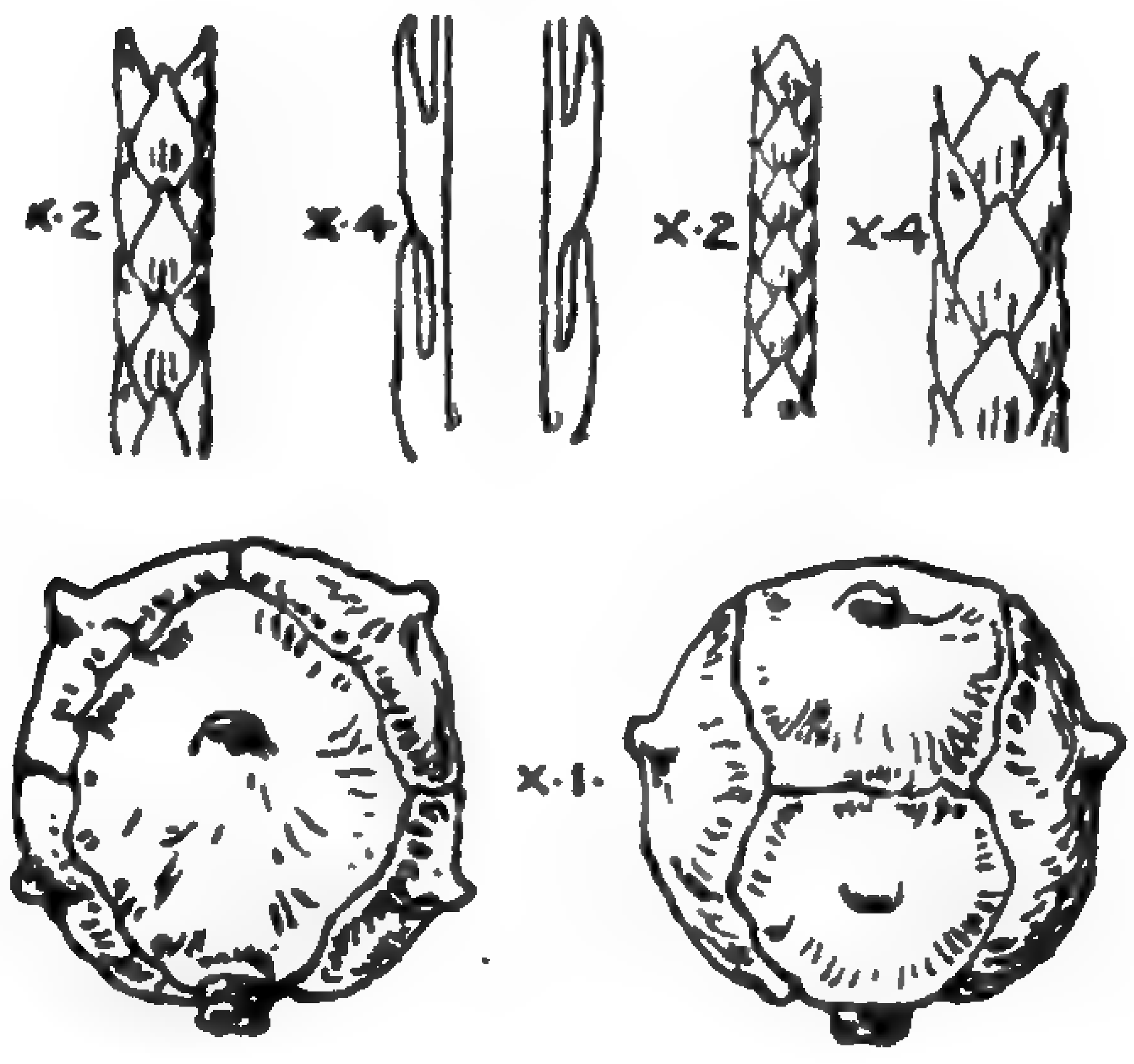
C. Lindleii, *Klotzsch in Endlicher, Synops.* p. 59 (1847); *Parlatore, l. c.* p. 471.

Cupressus thurifera, *Lindley in Bot. Reg.* (1839), App. p. 64; *Benth. Plant. Hartweg*, p. 57, *haud H. B. et K.*
? C. cornuta, *Carrière in Revue Horticole*, 1866, f. 32.
Jeffrey 1481!

Var. ARIZONICA; foliis insigniter glaucis; strobilis globosis magnitudine cerasi magni, squamis irregulariter 4–5-angulatis planiusculis versus apicem parum umbonatis.

In montibus Arizonæ, San Francisco dictis, *Greene*!; in mont. Santa Catalina, *Parry et Palmer* 848 partly!; Sierra Madre, *Lemmon* 1293!; Santa Rita, *Pringle*!; mont. Chirricahua, *Lemmon*!

Fig. 14.



C. Benthami, var. *arizonica*.—Foliage and section magnified, cones real size.

Cupressus arizonica, *Greene in Bulletin of the Torrey Botanical Club*, vol. ix. May 1882, p. 64; *Rusby in Bull. Torrey Bot. Club*, ix. 79; *Sereno Watson in Proc. Amer. Acad. Sci.* xviii. 1883, p. 157; *C. S. Sargent, Tenth Census Report*, 1884, p. 180, excl. syn.; *Lemmon, Third Report of the Californian State Board of Forestry*, 1890, p. 180; *Mast. in Gard. Chron.* ser. III. x. (1891), Sept. 26, p. 364.

Var. KNIGHTIANA.

C. Knightiana, *Knight & Perry, Gordon Pinetum*, 1858, p. 61; *Hansen in Journ. R. Hort. Soc.* vol. xiv. (1892), p. 284. *C. elegans*, hort.

"The origin of the species is unknown," *Knight & Perry, l. c.* Mexico, *Bourgeau*, 3258!

Specimina culta ex hort. Glasnevin pluribusque aliis observavi.

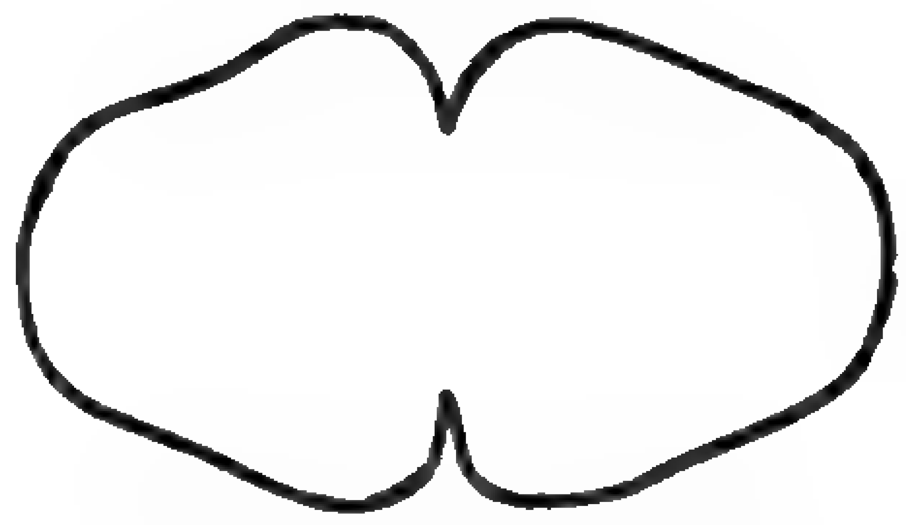
An species distincta? habitu formosa nisi in hortis vix

Fig. 15.

C. Benthami, var. *Knightiana*.—A. Herbaceous shoot of natural size, to show the regularity of its branching. B. A shoot of the second order, to show the approximately equal length of the branchlets of the third order, magnified 2 diams. C. Male inflorescence, magn. 4 diams. D. Imperfect anther from the inner side. E, F, G. Cones and cone-scales: these cones are imperfectly developed; generally they are considerably larger.

nota. Ab affinibus discrepat habitu regulari et præsertim conorum squamis valde pyramidatis, appendice foliaceo in medio squamæ et cum eâ fere omnino concrescente itaque inconspicuo.

Fig. 16.

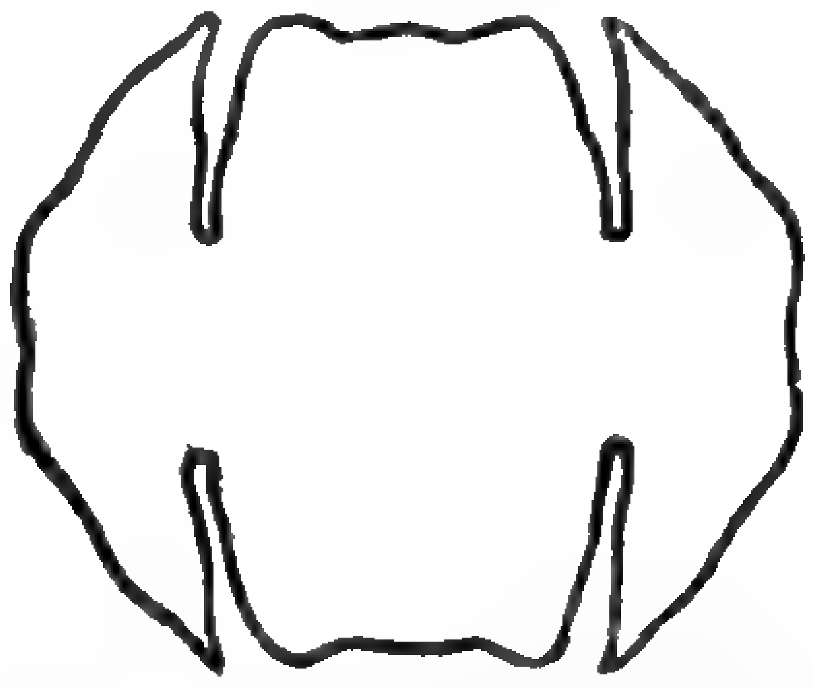


Cupressus Benthami, var. *Lindleii*.—Section across a pair of lateral leaves. × 20.

The leaf-section of *C. Benthami* var. *Lindleii* shows a suborbicular or ovate, very obtuse outline. The hypoderm is discontinuous, and the palissade well-marked.

In *C. Benthami* var. *arizonica* the outline of the section is semi-elliptic, very acute at the extremities, dorsally convex, flattened on the inner surface. The epidermis is very thick. The hypodermal layer is continuous, and the palissade well-marked, traversed by four-sided spiral vessels.

Fig. 17.



C. Benthami, var. *arizonica*.—Section across lateral and median leaves.

6. Cupressus macrocarpa, *Hartweg in Journ. Hort. Soc. Lond.* ii. (1847) p. 187, c. ic.

Arbor comâ effusâ horizontali vel pyramidatâ, ramis teretibus rubellis arcuatis; foliis ramealibus deltoideis acutis; ramis herbaceis oblongis acutis elongatis planiusculis subregulariter bipinnatim ramulosis; ramulis gracilibus subæqualibus subtetragonis; foliis vix 2 mill. long. facialibus crassiusculis deltoideo-oblongis obtusiusculis crebre eglandulosis seu glandulâ lineari præditis, apice parum patentibus; amentis masculis ovato-globosis; strobilis aggregatis breve pedunculatis majusculis oblongis obtusis vel subglobosis 2–3 cent. diam., squamis angulatis rugosis umbonatis seu umbilicatis; seminibus triquetris dorso convexis anguste alatis.

Cotyledones 2 patentes lineares, foliorum primordialium duo primotina cotyledonibus approximata, sequentia tetrasticha decussata internodio sublevata.

In nemorosis Californiæ prope Monterey, *Hartweg* 1970!, *Pringle*!, *Gray and Hooker*!; ad Cypress Point, *Bolander*, "Pescadero Ranch et Carmelo Point," *teste Sargent*; San Diego, *Palmer* 460.

Bentham, Pl. Hartweg, p. 337 (1849); Gordon in Journ. Hort. Soc. London, iv. (1849) 296, c. ic., et in Gard. Chron. (1849) p. 679; Pinetum, ed. II. p. 91; Torrey, Mexic. Bound. Survey, 211; Parlatore in DC. Prod. xvi. II. p. 473; Engelmann in S. Watson, Bot. Californ. ii. p. 113; A. Murray in Lawson Pinet. Brit. ii. p. 195, t. 32; Veitch, Manual, p. 234; Lemmon, Third Report (1890), tt. 25, 26; Sargent, Tenth Census Report (1884), p. 279, ubi loci libellares plurimi proferuntur; J. D. Hooker in Gard. Chron. Feb. 7, 1885, p. 176, c. ic.; Sargent in Garden and Forest, June 20, 1894; Beissner, Handbuch, p. 103; Kew Index, i. p. 671.

C. Lambertiana, *Carrière, Traité*, ed. II. p. 166.

Ic. xylog.: Journ. Hort. Soc. Lond. iv. (1849) p. 297; Gard. Chron. (1849) p. 679; Revue Horticole (1870), 191.

C. Hartwegii, *Carrière, Traité*, ed. II. p. 168.

C. torulosa, *Lindley & Paxton, Flower Garden*, vol. i. (1850), p. 167, fig. 105; *Van Houtte, Flore des Serres*, vii. 192; *Garden*, Jan. 17 (1885), p. 39, *haud Don*.

C. Reinwardtii, *hort.*

Var. FASTIGIATA; comâ conicâ; ramis fastigiatis. *Knight & Perry, Synops.* 20.

C. Hartwegii fastigiata, *Carrière, l. c.*

Var. LAMBERTIANA; ramis patentibus; foliis appressis obtusis.

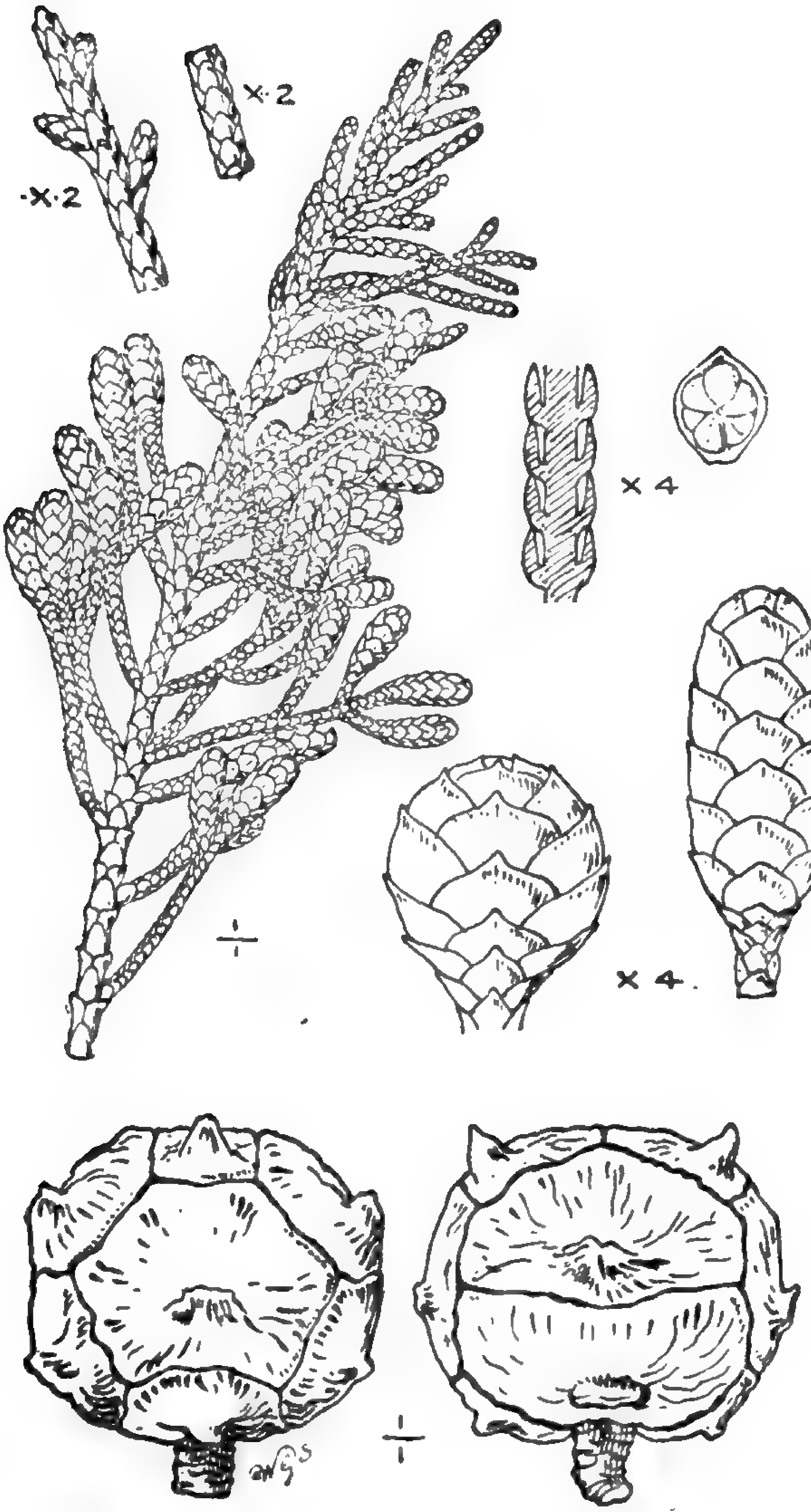
C. Lambertiana, *Carrière, Traité*, ed. II. p. 166.

Var. GUADALUPENSIS; comâ patulâ; ramis herbaceis oblongis subregulariter laxe pinnatim ramulosis, ramulis curvatis subtetragonis; foliis glaucis subeglandulosis; strobilis subglobosis.

Cupressus guadalupensis, *S. Watson in Proc. Amer. Acad.* (1879), xiv. p. 300; *Sargent, Tenth Census Report*, p. 180.

Ins. Guadalupe, Californ. merid., *Palmer* 92!; *Franceschi*!

Fig. 18.



Cupressus macrocarpa, var. *guadalupensis.*

? Var. FARALLONENSIS; frutescens, foliis argenteis lineari-oblongis; strobilis subglobosis oblongis obtusis parvis (2 cm. long.), squamis oblongis obtusis vel subangulatis, bracteâ longe concrescente apice acuto tantum liberâ. Jam *C. Govenianæ* forma?

Insul. Farallonens., Californiæ?

The Farallones Cypress, *J. Ellis in herb. Kew.*

Var. CRIPPSII; foliis patentibus rigidis acutis argenteis.

This corresponds to the "plumosa" or intermediate stage of growth of *Cupressus* (*Retinospora*) *pisifera.*

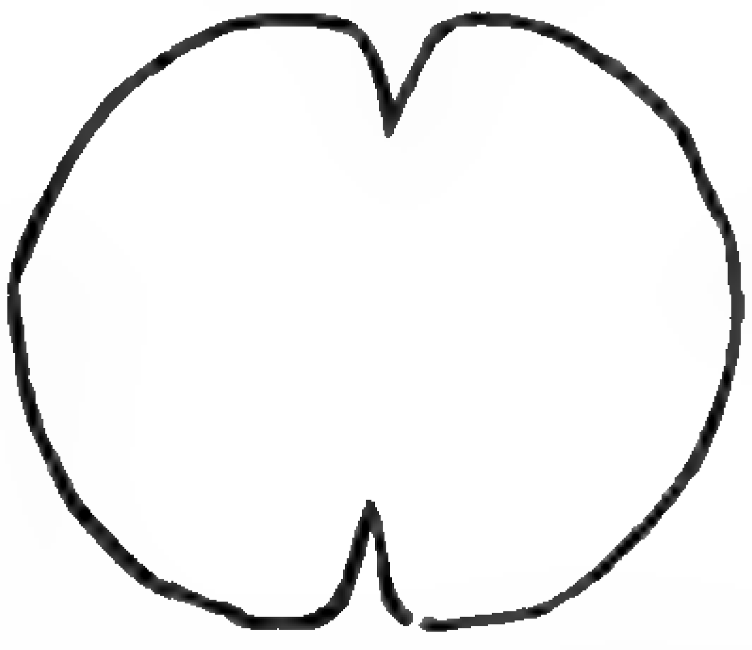
The form found at Monterey by Hartweg is a flat-topped tree like a Cedar of Lebanon. Sir Joseph Hooker, *supra* (p. 343) *citat.*, also says that he saw only the spreading branched form at Monterey,

in a wild state, and never the pyramidal form. This latter, however, is the one almost exclusively cultivated in California.

Carrière maintains the distinction between *C. Hartwegii* and *C. Lambertiana* (Traité, ed. II. p. 167). According to him, *C. Hartwegii* has more numerous, shorter, more dense (*confuses*), and more upright branches than *C. Lambertiana.* Moreover, the branches and branchlets are more elongated and slender, its leaves more distant, spreading, acuminate, and mucronate; whilst in *C. Lambertiana* they are imbricate, adpressed, and obtuse. *C. Hartwegii* is more tender in cultivation, while *C. Lambertiana* supports frost without injury. The two extreme forms are distinguishable in British gardens; but the difference between them is not sufficient to warrant the formation of two species.

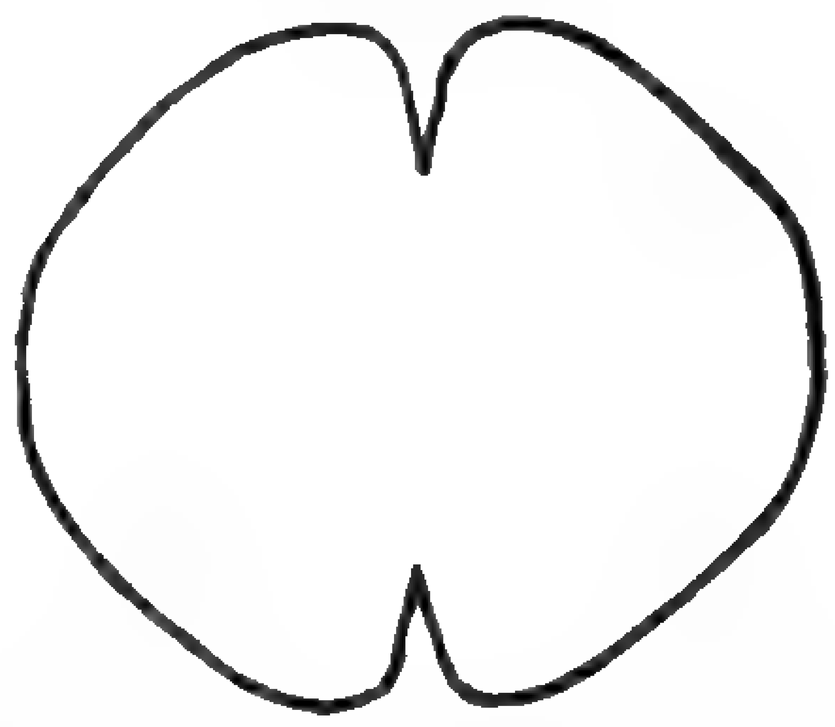
As to the Farallones variety above mentioned, there seems to be some doubt, as the islands, as I am told by Prof. Greene, are little better than barren rocks and only with difficulty accessible. The information given in a letter, dated Sept. 2, 1877, by Mr. John Ellis to Sir Joseph Hooker, and preserved in the Kew herbarium, runs as follows:—"Collected by a German on the Farallones Islands about 30 miles from the Golden Gate in the Pacific Ocean about seven years ago. It is a compact, upright, small tree, silvery in colour, and having a nearly round cone, and quite distinct in habit and colour from *C. macrocarpa.* The growth is more compact than the latter, and [it is] much slower in growth. The branching immediately from the ground. I have an impression that it is from *macrocarpa*, but the seeds from this variety all come true. I have called this variety, for want of a name, '*argentea.*' Seeds of all Cypresses here [are] more or less abortive." Mr. Ellis was the University Gardener at the time the letter was written. Prof. Sargent, *in litt.*, refers the plant to *C. Goveniana.*

Fig. 19.



Cross section of lateral leaves of *C. macrocarpa.* × 20.

Fig. 20.



Cross section of lateral leaves of *C. macrocarpa*, var. *guadalupensis.*

The outline of a cross section of the lateral leaves of *macrocarpa* is suborbicular. The epiderm is sometimes raised into papular cells, and the palissade is imperfect.

7. Cupressus Goveniana, *Gordon in Journ. Hort. Soc. Lond.* iv. (1849) p. 295, c. ic.

Arbor seu arbuscula comâ effusâ seu pyramidali, ramis teretibus rubris horizontaliter patentibus seu ascendentibus; foliis ramealibus longe concrescentibus appressis homomorphis deltoideis; ramis herbaceis ambitu oblongis angustis elongatis 1–2 pinnatim ramulosis, ramulis tetrastichis sæpe decussatis, gracilibus, laxiusculis brevibus tetragonis; foliis 1–2 mill. long. laxe imbricatis, facialibus ovato-oblongis obtusiusculis vel subacutis convexis glandulosis; amentis 2 mill. long. oblongis obtusis; strobilis aggregatis breviter pedunculatis 15 mill. diam. globosis, squamis leviusculis seu rugulosis medio breviter pyramidato umbonatis; bracteâ fere omnino cum umbone concrescente; seminibus oblongis obtusis anguste alatis.

Folia primordialia brevia subulata pungentia basi concrescentes apice libera patentes.

Fig. 21.

C. Goveniana.—Herbaceous shoot, foliage, and catkin.

California, prope Monterey in montibus primo detexit, *Hartweg* n. 1971! *Lobb* 10! "Humboldt County south along the coast, and through the coast-ranges into Lower California," *Sargent*!; St. Helena Cañon, *Pringle*!; Santa Lucia in montes, *Vasey*!; Santa Cruz, *Marcus Jones*, 2355!; loc. haud cit., *Kellogg & Harford*, 932!; Mendocino Plains, *Pringle*!

Gordon, Pinetum, ed. ii. 83; Benth. Plant. Hartweg (1849), 337; Torrey, Mex. Bound. Survey, 211; Parlatore in DC. Prod. xvi. ii. 471; Engelmann in S. Watson, Bot. Californ. ii. 114;

Kent in Veitch, Manual, 230 (1881); Sargent, Tenth Census Report (1884), 179.

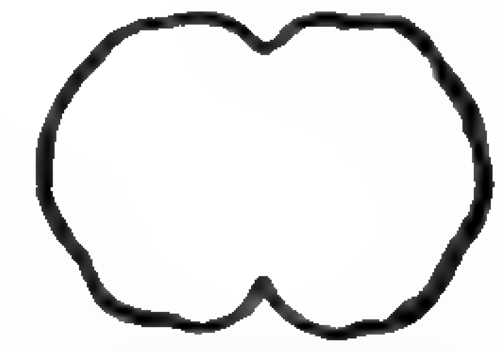
Ic. xylog. in Journ. Hort. Soc. iv. (1849) p. 295.

Cupressus californica, *Carrière, Traité*, ed. II. p. 164.

? C. cornuta, *Carrière in Rev. Hort.* 1866, p. 231, c. ic. xylog., an ad *C. Benthami* rectius referenda ?

Varietates hortenses *glauca*, *Huberiana*, *gracilis*, *viridis*, *attenuata* ?, Carr. ed. II. p. 171.

Fig. 22.



C. Goveniana, × 30.

The outline of a cross section of the lateral leaves is suborbicular. Beneath the epiderm is a single layer of hypoderm. The palissade-cells are imperfectly developed, and the ground-tissue traversed by a resin-canal.

8. Cupressus Macnabiana, *A. Murray in Edinb. New Phil. Journ.* i. p. 293, tab. 11; et *Descript. Conif. Californ.* p. 12, t. 10.

Arbor mediocris confertim ramosissima, ramis teretibus fusco-purpureis deflexo assurgentibus; foliis ramealibus undique positis remotiusculis deltoideo-lanceolatis apice subpatulis; ramis herbaceis ambitu triangulari-oblongis tripinnatim ramulosis, ramulis gracilibus subancipitibus subtetragonis apice sursum curvatis; foliis ultimis imbricatis atro-viridibus circa 2 mill. long. facialibus oblongis subrhombeis obtusiusculis dorso insigniter convexis glandulâ orbiculari munitis apice sæpius gibbis; foliis lateralibus naviculari-conduplicatis; amentis circa 3 mill. long. oblongis obtusis v. subglobosis; strobilis aggregatis breve pedunculatis globosis, diam. 2 cent. rufo-brunneis, squamis angulatis rugulosis umbonatis; bracteâ oblongâ cum umbone concrescente, squamæ sub apice liberâ, obtusiusculâ, subfoliaceâ.

California, in montibus Shasta ad 5000 ped., *Jeffrey*, specimen authenticum!; Sierra Nevada, *Lobb* 398! 439!; *Brewer* 863!; *Pringle*. "Mountains south of Clear Lake, Lake County," *Sargent*.

Lindley in Gard. Chron. 1855, p. 420; Gordon, Pinetum, ed. II. p. 90; Carrière, in Revue Horticole, 1870, p. 155, c. ic.; Parlatore in DC. Prod. xvi. II. p. 473; Engelmann, in S. Watson, Bot. Californ. ii. p. 114; Kent in Veitch Manual, p. 233; Beissner, Handbuch, p. 100.

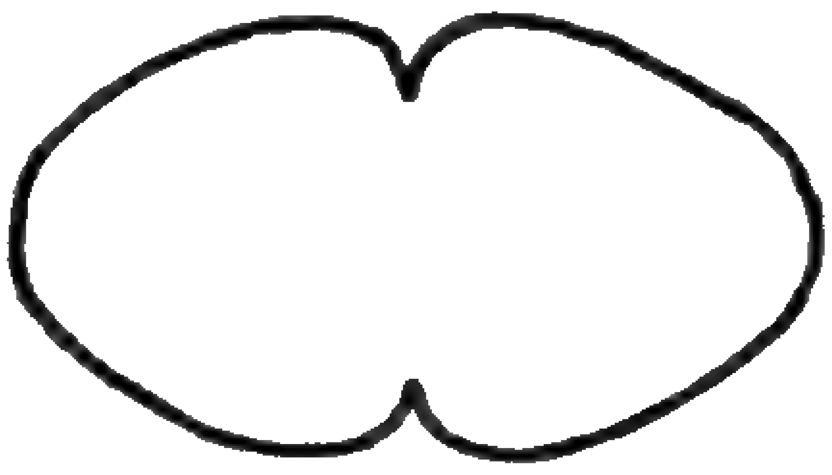
Icones:—Murray, *loc. cit.*: Carrière, *loc. cit.*; Gard. Chron. (1891), March 28, p. 403, ic. Carrière repetit. (see fig. 23); Florist & Pomologist (1874), f. 88; Revue Horticole (1870), p. 155.

Cupressus nivalis, Lindley MSS.; *C. glandulosa*, W. Hook. MSS.; *C. Coulteri*, hort. Glasnevin, e seminibus per annos viginti et unum in herbario cl. Coulteri asservatis in horto Glasnevin genita. [Vix *C. Coulteri*, Forbes, Pinet. Woburn. (1839), p. 190.]

Fig. 23.

C. Macnabiana.—Foliage and cones (*Revue Horticole*).

Fig. 24.



Section across lateral leaves of *C. Macnabiana.*

In section the lateral leaves are ovate or suborbicular, with a thick epidermis raised into papules on the inner surface. There is no hypoderm, and the palissade is imperfectly developed.

9. Cupressus thurifera, *Humb. Bonpl. et Kunth, Nov. Spec. et Gen.* ii. p. 3, ex *Parlatore in D.C. Prod.* xvi. ii. 473.

"Arbor, ramis patentibus, inferioribus apice reflexis, ramulis subdistichis brevibus teretiusculis; foliis ramorum ternis subimbricatis, ramulorum decussatim oppositis quadrifariam imbricatis, omnibus oblongo-lanceolatis inferne adnatis superne patulis acuminatis mucronato-pungentibus dorso convexis et in sicco glandulâ depressâ lineari-oblongâ prope medium notatis; amentis masculis numerosis in ramulo recto longiusculo erectis oblongis obtusis; bracteis late ovato-rotundatis obtusiusculis dorso convexis; strobilis in ramulo brevi erectis vel subcernuis globosis (fuscis glaucescentibus); squamis 6, [peltatis] decussatim oppositis crassiusculis lignosis, prope medium apice bracteæ libero brevi obtusiusculo patenti-reflexo notatis leviusculis, nuculis in quavis squama 2–3 fere obovatis convexo-triquetris apteris."

In silvis Mexici prope Tasco et Tehuitotepec, alt. 5500 ped. *Humb. et Bonpl.* 3956!; Masatlan, *Humboldt*!; in Mexico, ? Michoacoa, *Uhde* n. 547; Oaxaca, *Uhde* n. 550!; ? in Sierra Madre, *Seemann*!

Juniperus thurifera, Humboldt!, in herb. Willd. n. 3956, et in herb. Paris! *Chamæcyparis thurifera*, Endl.! Conif. p. 62; Carr. Conif. p. 135; Gord. Conif. p. 50; "*Cedro*," Mexic. Strobili 10–13 mill. longi et fere ejusdem mensuræ lati.

"Species squamarum et nucularum pericarpio osseo alis destituto præditarum structurâ a Chamæcypari aliena et inter Cupressos adnumeranda (*v. s.*)."—*Parlatore, l. c.* p. 474.

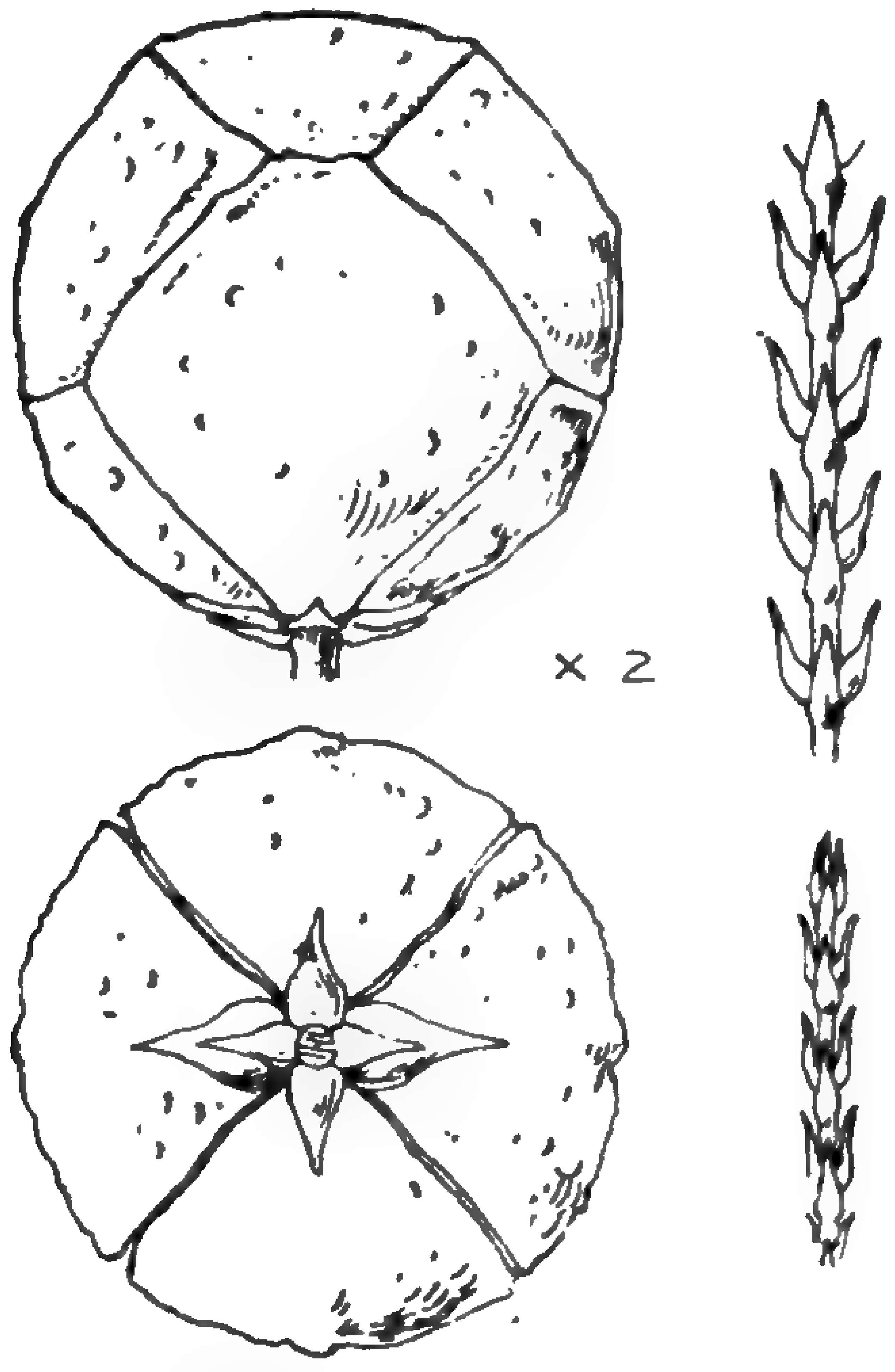
Cupressus Uhdeana, Gordon, ad hanc speciem ab ipso auctore relata est vide Gordon, Pinetum, ed. ii. (1875) p. 100; cfr. etiam ad *Cupressum Benthami*.

Adsunt etiam in Musæo Kewensi strobili a Botteri ad Orizabam lecti huic speciei forsan tribuendi (fig. 27, p. 351). Strobili subglobosi magnitudine fructûs *Pruni spinosæ*. Squamæ 6 sublignosæ haud peltatæ parum angulatæ dorso planiusculæ seu sulco longitudinali notatæ. Bracteæ nisi ad apicem extremum cum squamis concrescentes. Semina sub quâvis squamâ 2, subtrigono-ovoidea, fere aptera seu alâ angustissimâ præditâ. De hac specie etiam conferendum cum adnotatione cl. Lindleii 'Gardeners' Chronicle,' 1856, p. 772, sub nom. *Chamæcyparidis thuriferæ*.

I owe to the kindness of M. Poisson and the Director of the Herbarium at the Muséum d'Histoire Naturelle, Paris, the privilege of inspecting in the herbarium the specimens collected

by Humboldt. To Dr. Urban, of Berlin, I am likewise indebted for the opportunity of seeing fragments of foliage in the Berlin Herbarium. The branches are erecto-patent, branchlets elongate; leaves tetrastichous, spreading, deltoid, subulate, glaucous. The Paris cone measures 14 mm. in length by 13 mm. in

Fig. 25.



Foliage and cone of *Cupressus thurifera*, H. B. & K. Herb. Paris.

Fig. 26.

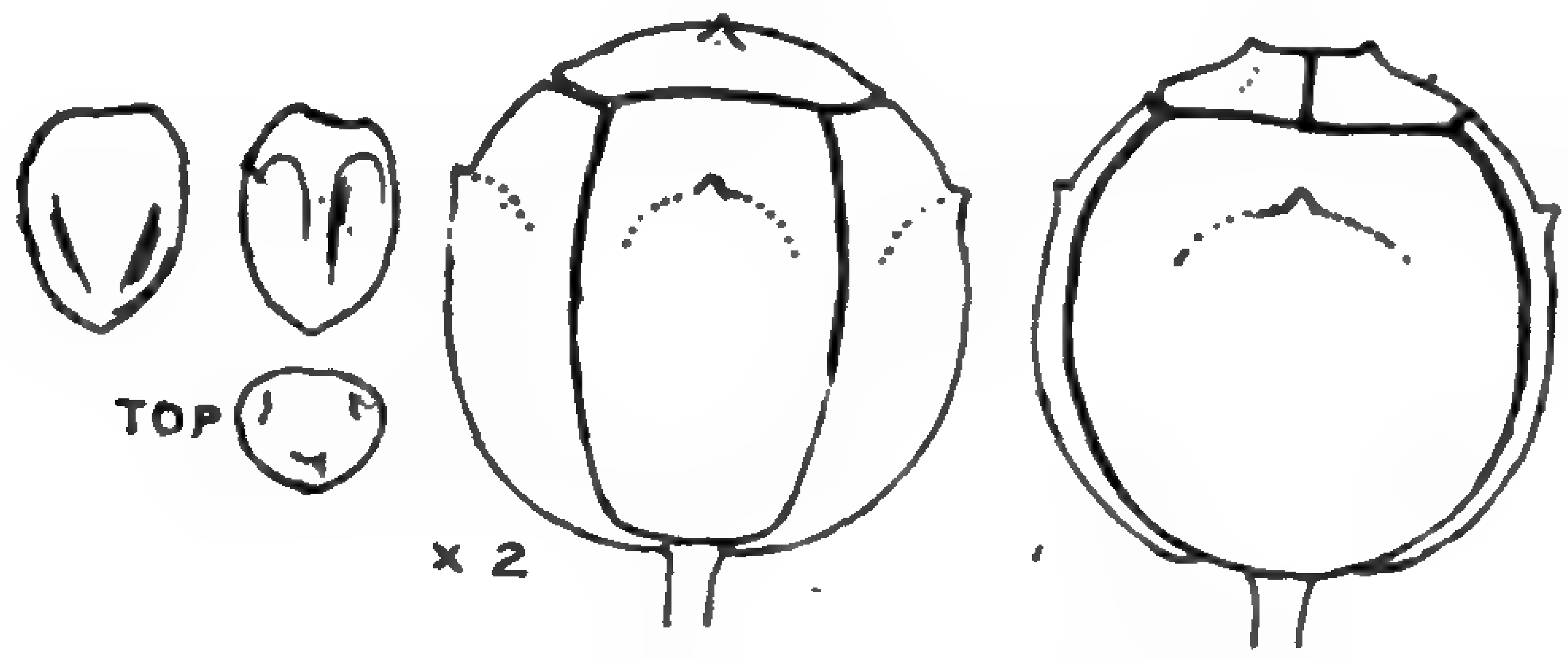
Foliage and seed of *C. thurifera*, H. B. & K., magn. Berlin.

breadth; it is subglobose or a little depressed at the apex; the constituent scales are woody, markedly peltate, 4-sided, convex, glaucous, tuberculate, and the bract is scarcely visible. The scales

are tightly adherent (valvate), and the whole cone resembles that of a true Cypress rather than that of a *Chamæcyparis.*

In its wingless seeds it seems to bear the same relation to *Cupressus* that *Biota* does to *Thuya,* and furnishes another indication that *Cupressus, Chamæcyparis, Thuya,* and *Biota* have all descended, relatively recently, from the same stock.

Fig. 27.



Cones of *Cupressus,* sp., from Botteri.

The cones collected by Botteri, just alluded to, have, in the dry state, their scales so widely separate that the cones resemble those of *Tetraclinis articulata,* and their peltate form is scarcely apparent. If, however, the cones be soaked in water, so as to restore the original form, a resemblance to Humboldt's *thurifera* becomes visible.

Subgenus CHAMÆCYPARIS.

Strobili sæpius parvi seu pisi magnitudine, primo anno maturescentes. Squamæ peltatim dilatatæ coriaceæ vel sublignosæ. Semina plq. 2, raro 3–4, sub quâvis squamâ. Ramuli ultimi sæpius distiche dispositi. Folia lateralia plus minus conduplicata, folia mediana complanata.

Cupressi, sp., *Linn. Sp. Pl.* 1422; *C. Koch, Dendrologie,* ii. II. 1873, p. 162, *et auct. var.*

Chamæcyparis, *Spach, Hist. Nat. Vég. Phan.* xi. 329; *Endlicher, Synopsis,* p. 60 (1847); *Carrière, Conif.* p. 132; *Gordon, Pinetum,* p. 48; *Parlatore, in DC. Prod.* xvi. II. p. 463; *Beissner, Handbuch* (1891), p. 65; *Eichler in Engler u. Prantl, Die natürlichen Familien,* ii. Teil, 1 Abteilung (1889), 99; *Engelmann in S. Watson, Botany of California,* ii. (1880), 114.

Chamæpeuke, *Zucc. in Endl. Enchir. Bot.* p. 139.

Retinospora, *Sieb. et Zucc. Fl. Jap.* ii. p. 36, *et auct.* (partim).

Thuya, sect. Chamæcyparis, *Benth. et Hook. Gen. Plant.* iii. 427; *Baillon, Hist. des Plantes,* "*Conifères,*" p. 35 (1892).

10. CUPRESSUS THYOIDES, *Linn. Spec. Pl.* ed. I. 1003, ed. II. 1422; *Aiton, Hort. Kew.* iii. 372; *Nouveau Duhamel,* iii. 6; *Loudon, Arboretum,* iv. 2475. f. 2327; *Forbes in Pinet. Woburn.* 183, t. 61; *Hook. Fl. Bor.-Am.* ii. 165; *A. Gray, Manual,* ed. v. 473; *C. Koch, Dendrologie,* ii. II. 162; *Kent in Veitch, Manual,* 238.

Cupressus nana Mariana, *Pluk. Mant.* 61, t. 345.

Chamæcyparis sphæroidea, *Spach, Hist. Vég. Phan.* xi. 331; *Endlicher, Synopsis,* 61; *Knight, Synops. Conif.* 20; *Carrière, Traité,* ed. II. 122; *Gordon, Pinetum,* ed. II. 71; *Parlatore in DC. Prod.* xvi. II. 464; *Sargent, in Tenth Census Report* (1884), 177; *Beissner, Handbuch,* p. 65.

Thuya sphæroidea, *Sprengel, Syst.* iii. 889; *Macoun, Cat. Canadian Plants,* part 1 (1883), p. 461.

Thuya sphæroidalis, *Richard, Conif.* 45, t. 8. f. 2.

"Southern Maine, south near the coast of Florida and along the Gulf Coast to the valley of the Pearl River, Mississippi," *Sargent, l.c.*; Cape Breton Island, and Three Mile House, Halifax, N.S., *Lawson ex Macoun*; New Jersey, *Torrey*!, *Michaux*!

Species bene cognita, in Floris Americanis boreali-orientalibus omnibus satis descripta. Adest specimen hujusce speciei in herb. Linnæano. In hortis adsunt varietates plurimæ habitu, coloreque foliorum distinctæ nempe. "*Retinospora ericoides,*" cfr. Beissner, Handbuch, p. 67 (forma foliis primordialibus demum violascentibus laxe patentibus prædita); *Retinospora leptoclada* alias *Chamæcyparis sphæroidea andeleyensis* (forma intermedia); *kewensis* alias *glauca*; *aurea*; *variegata*; *atrovirens*; *pyramidata*; *fastigiata*; *pendula*; *nana*; *pygmæa*; *Hoveyi* (forma ramulis fasciatis etc.).

11. C. NOOTKATENSIS, *Lambert, Pinus,* ed. II. i. 18; *Loudon, Arboretum,* iv. 2480.

Cupressus nutkaensis, *Hook. Fl. Bor.-Am.* ii. 165; *Gordon, Pinetum,* 66, ed. II. 94; *Lawson, Pinetum Brit.* ii. 199, t. 34. ff. 1–12; *C. Koch, Dendrologie,* ii. II. 165; *Kent in Veitch, Manual,* 235.

Cupressus americana, *Trautvetter, Imag. Pl. Fl. Rossica,* 12, t. 7 (1844).

Chamæcyparis nutkaensis, *Spach, Hist. Vég. Phan.* xi. 333; *Endlicher, Synopsis,* 62; *Ledebour, Flora Rossica,* iii. 680; *Carrière, Traité,* 134, ed. II. 127; *Parlatore in DC. Prod.* xvi. II. 475; *Sargent in Tenth Census Report,* 178; *Beissner, Handbuch* (1891), p. 79, f. 15; *Revue Horticole,* 1869, p. 48.

Thuya excelsa, *Bongard in Mém. Acad. St. Pétersbourg*, sér. VI. ii. 164; *Macoun, Cat. Canad. Plants*, part 1 (1883), p. 461.

Thuyopsis borealis, *Carrière, Traité*, ed. I. 113.

Thuyopsis cupressoides, *Carrière, in Man. des Plantes*, iv. 324.

"Sitka, south along the islands and coast ranges of British Colombia and the Cascade Mountains of Washington territory and Oregon, to the valley of the Santian River, Oregon," *Sargent, l. c.*; *Bongard*! Mount Hood, *Pringle*!; *Howell*! Behind Banks Island, *Menzies*; Vancouver, *Dawson*, 2064. Sitka, *Mertens*!; British North America, *Richardson, Lemmon*!

Species in libris affatim descripta et in herbariis facile recognita. In hortis variat habitu coloreque unde formæ hortenses, *viridis, aurea, glauca, aureo-variegata, argenteo-variegata*, nec non *pendula, compacta, gracilis, nidiformis*, etc.—Beissner, *l. c.* p. 82. In hortis anglicis foliis deltoideo-subulatis sæpius gaudet. Specimina indigena folia imbricata oblonga obtusiuscula monstrant.

A cross section of the lateral leaves shows an ovate triangular outline, with epiderm, one layer of hypoderm, and ground-tissue with a resin-canal passing through it.

12. CUPRESSUS LAWSONIANA, *A. Murray in Edinb. New Phil. Journ.* new series, i. 292, t. 9; *Gard. Chron.* 1855, 372; *Bot. Mag.* t. 5581; *A. Murray in Lawson Pinet. Brit.* ii. 191, t. 31. ff. 1–13, *et in Journ. Linn. Soc.* (*Bot.*) xxvii. 312; *Kent in Veitch Manual*, 231; *Eichler in Monatsb. Akad. Berlin*, 1881, ff. 29–30.

Cupressus fragrans, *Kellogg in Proc. Calif. Acad.* i. 103.

C. attenuata, *Gordon, Pinetum*, ed. I. 57, ed. II. 79.

C. Boursieri, *Carrière, Traité*, ed. II. 125, *an Decaisne?*

C. nutkanus, *Torrey in Bot. U.S. Explor. Exped.* t. 16.

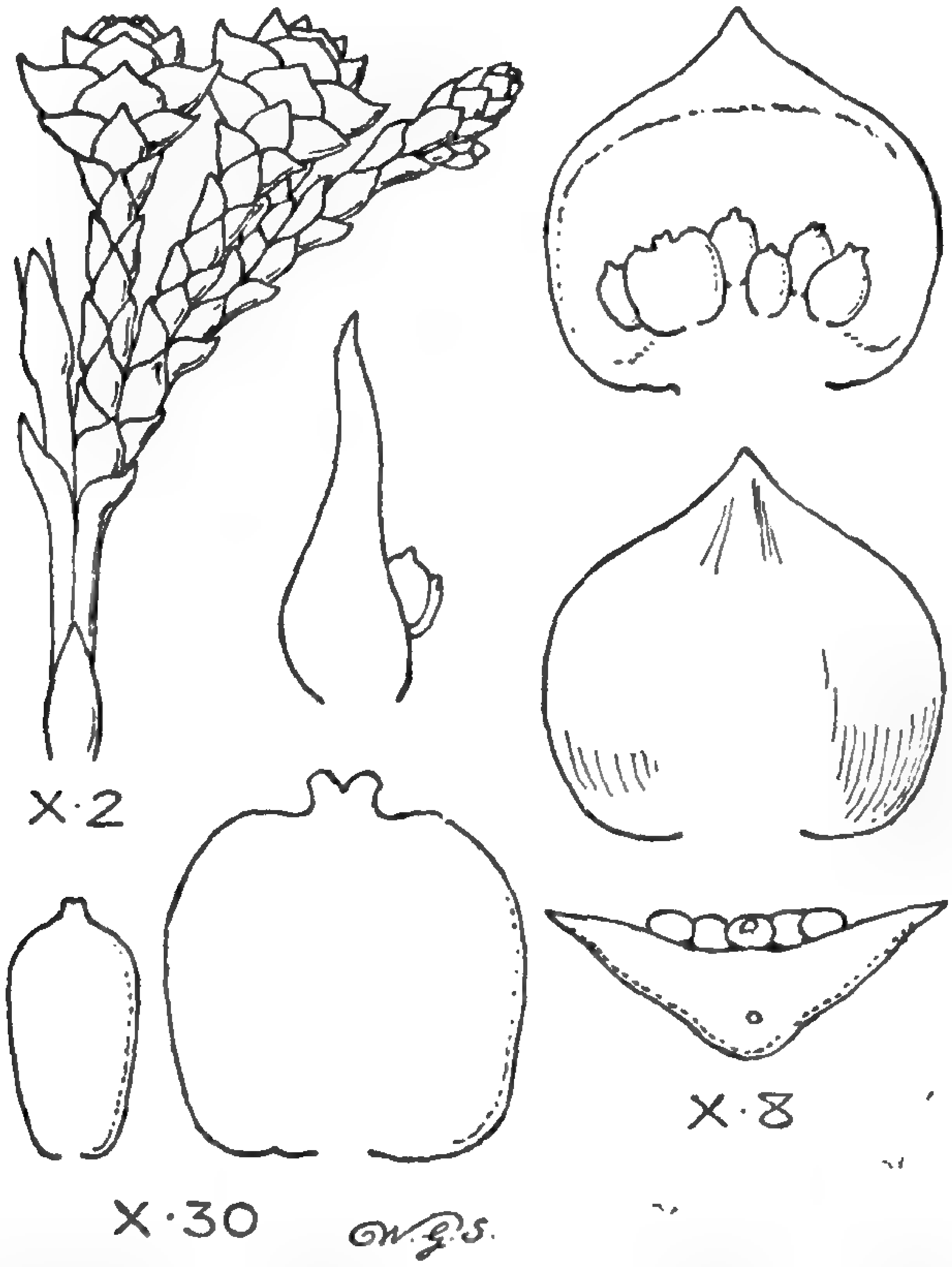
C. Bourgeauii, *hort., fide Gordon, Pinetum*, ed. II. 79.

Chamæcyparis Lawsoniana, *Parlatore, Stud. Org. Conif.* 23, 29, t. 3, *et in DC. Prod.* xvi. II. 464; *Gordon, Pinetum*, ed. II. 85; *Engelmann in S. Watson, Bot. Californ.* ii. 155; *Sargent in Gard. Chron.* 1881, 8, *et Tenth Census Report*, 178; *Beissner, Handbuch* (1891), p. 70, fig. 17; *Lemmon in Third Biennial Report* (1890), t. 24, p. 177; *Wiener Gart. Zeitung*, 1885, p. 493.

California, *Murray*!; "Oregon, Coos Bay to the valley of the Rogue River, not extending more than thirty miles from the coast; California, valley of the Upper Sacramento River; Shasta County."—*Sargent, l. c.*; *herb. Hance* 22068; *Bridges* 289!

Species haud difficile recognescenda et in libris bene descripta. Quoad habitum, foliorumque colorem miro modo variat. *Cupressus Lawsoniana erecta viridis*, hort. (*vid.* fig. 5, p. 320), est forma fastigiata foliis insigniter viridibus. Ramificationis modo diversæ sunt formæ quibus nomina sequentia propria in hortis sunt tributa,—*erecta*, *pyramidalis*, *monumentalis*, *robusta*, *pendula*,

Fig. 28.



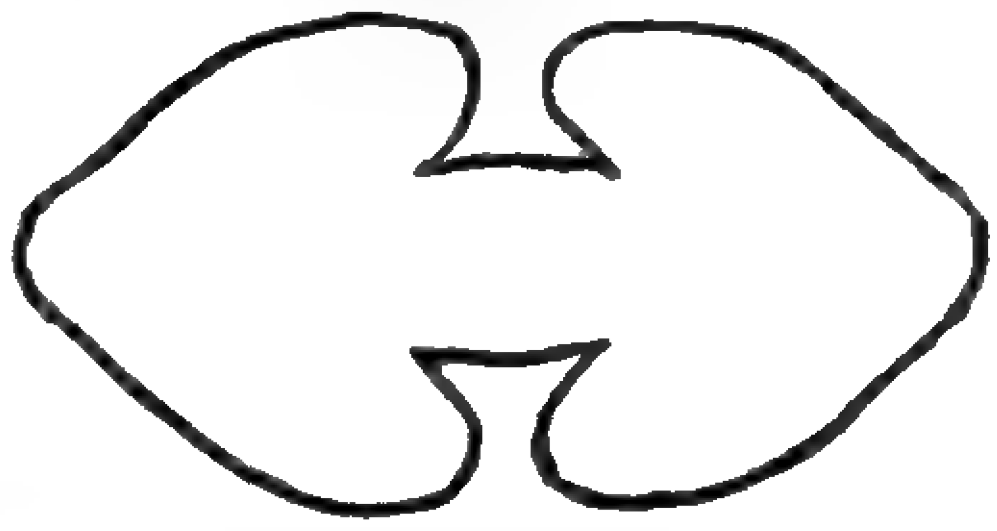
Cupressus Lawsoniana.—Young cone, scales, and seeds.

filiformis, *intertexta*, *gracilis*, *laxa*, *crispa*, *tortuosa*, *compacta*, *minima*, *nana*, *prostrata*, aliæque. Colore foliorum distinguendæ formæ sequentes *glauca*, *aurea*, *lutea*, *lutescens*, *argentea*, *nivea*, *versicolor*, *argenteo-variegata*.

Formæ hæc ce juventute proprie definitæ, tamen in adolescentia sæpe diffugiunt et in arbore maturâ, inconspicuæ evadunt.

A cross section of a lateral leaf shows a cordate ovate subobtuse outline. The outer epiderm is thickly cuticularized, the hypoderm discontinuous in a single layer, the palissade-cells imperfect, and the parenchyma traversed by a resin-canal.

Fig. 29.



C. Lawsoniana, leaf-section.
Young's variety.

13. CUPRESSUS OBTUSA, *C. Koch, Dendrologie,* ii. II. p. 168.

Retinospora obtusa, *Sieb. et Zucc. Fl. Jap.* ii. p. 38, t. 121; *Gordon, Pinetum,* ed. II. 367; *Kent in Veitch, Manual,* 245, fig. 56; *Gard. Chron.* 1861, p. 264; *Mast. in Gard. Chron.* Feb. 19, 1876, p. 236; *Revue Horticole,* 1869, p. 97.

Thuya obtusa, *Mast. in Journ. Linn. Soc.* (*Bot.*) xviii. 491, c. ic.

Chamæcyparis obtusa, *Sieb. et Zucc. ex Endlicher, Synopsis,* 63; *Beissner, Handbuch,* p. 92, fig. 25; *Parlatore in DC. Prod.* xvi. II. 466.

Japan, *Siebold*!; *Oldham* 354, 796, 797!; *Maximowicz, Iter,* 2!; *Fortune*!; *Veitch*!; *Hance* 8278!

Var. BREVIRAMEA.

Chamæcyparis breviramea, *Maximowicz in Bull. Acad. St. Pétersb.* x. (1866) p. 489; *Beissner, Handbuch,* p. 97.

Thuya obtusa, var. breviramea, *Mast. in Journ. Linn. Soc.* (*Bot.*) xviii. p. 494.

Retinospora filicoides, *hort.*; *Maximowicz ex Hance* 17936 *in Mus. Brit.*!

Var. PENDULA.

Chamæcyparis pendula, *Maximowicz, l. c.*

Ramuli elongati graciles complanati. Folia glanduligera, appressa oblonga ad apices deltoidea acuta.

Maximowicz! *Savatier*!

Homologiam præbet cum *Thuyâ* (*Biota*) *orientali* var. *pendulâ.*

Inter formas hortenses enumerantur varr. *erecta, magnifica, Keteleerii, pendula, nana, gracilis, pygmæa, filicoides* (Journ. Linn. Soc. (Bot.) xvii. 494, c. ic.), *Troubetzkoyana, tetragona-aurea, aurea, albo-spica, lycopodioides* (fasciata), aliæque habitu vel colore a typo divergentes et plerumque sub genere falso *Retinospora*" inclusæ.

Folia primordialia linearia patentia, folia intermedia homomorpha lineari-oblonga obtusa convexa; folia exoleta dimorpha, mediana plana ovato-oblonga obtusa, lateralia conduplicata.

14. C. PISIFERA, *C. Koch, Dendrologie,* ii. II. 170.

Retinospora pisifera, *Sieb. et Zucc. Fl. Japon.* ii. t. 122;

Gordon, Pinetum, ed. II. 369; *Kent in Veitch Manual*, 241; *Mast. in Gard. Chron.* Feb. 19, 1876, p. 237.

Thuya pisifera, *Benth. et Hook., Mast. in Journ. Linn. Soc.* (*Bot.*) xviii. p. 489, c. ic.

Chamæcyparis pisifera, *Sieb. et Zucc. ex Endlicher, Synopsis*, 64; *Gard. Chron.* (1861), 265; *Parlatore in. DC. Prod.* xvi. II. 465; *Beissner, Handbuch* (1891), p. 83, fig. 20.

In Japoniâ, *Kæmpfer*; *Siebold*!; *Oldham* 401!; *Zollinger* 157!; *Buerger*!; *Maximowicz*!; *Fortune*!; *Wright*!; *Veitch*!; *Savatier* 1194!; spontanée dans les montagnes, *Abbé Faurie* 3486!; spec. cult. 3488, 6330, 6331, 6333, 6334, 6335, *Abbé Faurie*!; in Imp. Sinensi, prov. Yunnan (culta), *Anderson*!, *Hance*!

Forma PLUMOSA; foliis lineari subulatis apice laxis. *Maximowicz*; *Hance* 14339! Forma intermedia=*Retinospora plumosa*, hort.

Forma PENDULA, *Maximowicz ex Hance* 15204!=*Retinospora filifera*, hort.; ramis gracilibus pendulis sparse ramosis foliisque homomorphis, patulis deltoideo-subulatis. *Vide* Mast. in Journ. Linn. Soc. (Bot.) xvii. 492, c. ic.

Forma SQUARROSA; foliis primordialibus laxe patentibus linearibus glaucis=*Retinospora squarrosa*, Sieb. & Zucc.

Foliorum color etiam variat unde formæ hortenses quibus nomina *alba, aurea, argentea, flavescens, aureo-variegata*, etc., etc.

The two preceding species, *C. obtusa* and *C. pisifera*, were placed by Bentham, together with other members of the section *Chamæcyparis*, in the genus *Thuya*, and in a previous communication I adopted the same arrangement. The shape of the cone-scales, the disposition of the ovules, and the form of the cone itself have, however, induced me to detach the species of *Chamæcyparis* from *Thuya* and to place them under *Cupressus*.

Chronological List of Authorities for Specific Names.
Those adopted are printed in roman, synonyms in italics.

1753, Linnæus, Sp. Plant. ed. I.	sempervirens. Thyoides. *disticha.*
1762, Linn. Sp. Plant. ed. II. 1422	*juniperoides.*
1768, Miller, Gard. Dict. ed. VIII.	lusitanica. *horizontalis.* *africana.*
1781, Linn. f. Suppl. 421	*japonica.*
1784, Thunberg, Flora Japonica	*pendula.*
1784, L'Héritier, Stirp. Nov. 15, t. 18	*pendula.*
1786, Forster fil., Florul. insul. austral. Prodrom.	*columnaris.*
1796, Salisbury, Prod. Stirp.	*lugubris.* *elongata.* *læta.* *humilis.* *palustris.*
1798, Staunton—An authentic account of an Embassy to the Emperor of China, ed. II. p. 446, tab. 41, "Weeping Thuya or lignum vitæ"	[funebris, *Endl.*]
1803, Lambert, Pinus, ed. I.	nootkatensis.
1807, Persoon, Synops. ii. 580	*patula.* *australis.*
1808, Targioni-Tozzetti, Oss. Bot. dec. iii.	*pyramidalis.* *Thuya.*
Id. ex Steudel, Nomencl. ed. II.	*expansa.*
1815, Candolle, A. P. de, Flor. Franç. v. 336.	*fastigiata.*
1816, Willdenow, Hort. Berol. Supp.	*bacciformis.*
1817, Kunth in Humboldt & Bonpland, Nov. Gen. et Spec. Plant. ii. 3	thurifera. *sabinoides.*
1825, Don, David, Prod. Flor. Nep.	torulosa.
1826, Spadoni, Xilogr. p. 193	*patula.* *conoidea.*
1830, Loudon, Hort. Brit. 388	*triquetra.*

1834, Audibert, Cat. ex Carrière	*Tournefortii.*
1838, Schlechtendal in Linnæa, xii. 493	*thurifera.*
1839, Forbes in Pinetum Woburnense	*articulata.* *Fothergilli.* *Coulteri.*
1842, Loudon, Encycl. Trees	*nepalensis.*
1843, Gillies in Hook. Lond. Journ. Bot. ii. 199	*chilensis.*
1844, Trautvetter, Plant. Imag. Ross.	*americana.*
1847, Hartweg in Journ. Hort. Soc. Lond. ii. 187	macrocarpa.
1847, Endlicher, Synops. Conif. 59	Benthami. funebris.
1847, Klotzsch in Endlicher, Synops. 59	*Lindleii.*
1847, Kunze in Linnæa, xx. 16	*Ehrenbergii.*
1847, Griffith, Notul. iv. 26	*pendula.*
1849, Gordon in Journ. Hort. Soc. Lond. iv. 295, ic.	*Goveniana.*
1850, Knight and Perry, Synopsis	*majestica.* *Corneyana.* *flagelliformis.*
1852, Tenore, Ind. Sem. Neap.	*Tournefortii.*
1855, Carrière in Revue Horticole..........	*Hartwegii.*
„ „ Traité, ed. I..................	*californica.* *Roylei.* *excelsa.*
1856, Kellogg in Proc. Calif. Acad. 103	*fragrans.*
1857, Murray in Edinb. New Philos. Journ.; and Descr. Conif. Californ. p. 12	Lawsoniana. Macnabiana.
1857, Regel, Gartenflora, 346	*Karwinskiana.*
1858, Gordon, Pinetum, ed. I.	*aromatica.* *attenuata.* *sinensis.* *squarrosa.* *australis.*
1858 (?), Nuttall ex Gordon, Pinetum	*imbricata.*
1860, Parlatore, Ind. Sem. Hort. Florent., et in Ann. Sc. Nat. sér. IV. xiii. 377	*umbilicata.* *globulifera.* *sphærocarpa.*
1862, Gordon, Supplement to Pinetum......	*bacciformis.* *Schomburgkii.*
1866, Carrière in Revue Horticole..........	*cornuta.*

1867, Carrière, Traité, ed. II.	lusitanica.
1873, C. Koch, Dendrol. ii. II. 170	pisifera. obtusa.
1873, C. Koch in Monatschr. i. 110	*amœna.*
1875, Gordon, Pinetum, ed. II.	*Bourgeauii. Balfouriana.*
1879, S. Watson in Proc. Amer. Acad. xiv. 300.	*guadalupensis.*
1882, Greene in Bull. Torrey Bot. Club, ix. 64	*arizonica.*

SYNONYMIA.

africana, Miller, Gard. Dict. viii. n. 6. =Widdringtonia juniperoides, *teste* Parlatore in DC. Prod. xvi. II. 442.
americana, Catesby, ex Endl. Syn. Con. 68. =Taxodium distichum.
americana, Trautvetter, Plant. Imag. Ross. 12, t. 7. =nootkatensis, *Lambert*.
amœna, C. Koch in Monatschrift Gart. Pflanz. i. 110, et in Dendrolog. ii. =funebris.
Arbor vitæ, Targ.-Tozz. Oss. Bot. dec. iii. 71. =Thuya occidentalis.
aromatica, Gord. Pinet. 56. =Benthami.
articulata, Forbes, Pinet. Woburn. 191. =Tetraclinis articulata.
attenuata, Gord. Pinet. 57. =Lawsoniana.
australis, Low, ex Gord. Pinet. 72. =sempervirens.
australis, Persoon (? Desfontaines), Syn. ii. 580. =Callitris rhomboidea.
bacciformis, Knight ex Gord. Pinet. Suppl. 38. =Juniperus occidentalis.
bacciformis, Willd. Enum. Hort. Berol. Suppl. 64, *fide* Index Kew. =Juniperus phœnicea.
Balfouriana, Lemoine ex Gord. Pinet. =(quid?)
Bourgeauii, hort. ex Gord. Pinet. ed. II. 79, *teste* Index Kew. =Goveniana.
brasiliensis, C. Koch, Dendrol. ii. II. 159. =thurifera, *fide* Index Kew.
breviramis, F. Muell. Sel. Pl. Indust. Cult. 64. =obtusa, var.
californica, Carrière, Traité, ed. I. =Goveniana.
cashmiriana, hort. =torulosa.
chilensis, Gillies, ex Hook. Lond. Journ. Bot. ii. (1843) 199. =Libocedrus chilensis.
columnaris, Forst. fil. Flor. Insul. Aust. Prod. 67. =Araucaria excelsa v. Cooki ?
conoidea, Spadoni, Xilogr. i. 189. =sempervirens.
Corneyana, Knight & Perry, Synops. =torulosa, var.
cornuta, Carrière in Rev. Hortic. 1866 (250). =Goveniana.

Coulteri, Forbes, Pinet. Woburn. 190. =? Benthami.
Cunninghami, hort. =Benthami.
Devoniana, hort. ex Beissner, Handbuch, 116. =Juniperus phœnicea.
disticha, Linn. Sp. Pl. 1003. =Taxodium distichum in herb. Linn.
Drummondi, hort. =torulosa.
Ehrenbergii, Kunze, in Linnæa, xx. (1847) 16. =Benthami.
elongata, Salisbury, Prodr. 397. =sempervirens.
excelsa, Scott, ex Carr. Conif. 128. =Benthami.
expansa, Targ.-Tozz. ex Steud. Nomencl. ed. II. i. 455. =sempervirens.
fastigiata, DC. Flor. Franç. v. 336. =sempervirens, var.
filiformis, hort. ex Parlatore, in DC. Prodr. xvi. II. 474. =Thuya orientalis, var.
flagelliformis, Knight & Perry, Synop. 20. =torulosa.
Fothergilli, Forbes, Pinet. Woburn. 191. =?Tetraclinis articulata.
fragrans, Kellogg, in Proc. Calif. Acad. i. (1850) 103. =Lawsoniana.
glandulosa, Hook. ex Gord. Pinet. 64. =Macnabiana.
glauca, La Marck, Encycl. ii. 243. =lusitanica, *Miller*.
globulifera, Parlatore, in Ann. Sc. Nat. sér. IV. xiii. (1860) 377. =sempervirens, var.
guadalupensis, S. Watson, in Proc. Amer. Acad. xiv. (1879) 300. =macrocarpa.
Hartwegii, Carrière, in Rev. Hortic. (1855), 233. =macrocarpa
horizontalibus (sic), Miller, Gard. Dict. ed. 8, n. 2. =sempervirens.
Hugeli, hort. =sempervirens.
humilis, Salisb. Prodr. 398, teste Indice Kewensi. =Callitris arborea.
imbricata, Nuttall, ex Gord. Pinet. 307. =Taxodium distichum.
japonica, Linn. f. Suppl. 421. =Cryptomeria japonica.
juniperoides, Linn. Sp. Pl. ed. II. 1422. =Widdringtonia juniperoides.
Kæmpferi, hort. =Goveniana.
Karwinskiana, Regel, Gartenflora (1857), 346. =Benthami, var.
læta, Salisbury, Prodr. 397. =Taxodium distichum.
Lambertiana, hort. ex Carr. Traité, 124. =macrocarpa.
Lindleii, Klotzsch, ex Endlicher, Synops. =Benthami, var.
lugubris, Salisb. Prodr. 397. =sempervirens.
lusitanica, Carrière, Traité, ed. II. 155. =Benthami.
lusitanica, Lindl. ex Parlatore, in DC. Prodr. xvi. II. 472. =Benthami, var.
macrostachya, hort. ex Parlatore, l. c. =Callitris Gunnii.
majestica, Knight & Perry, Synops. =torulosa, var.
mexicana, C. Koch, Dend. ii. II. 159. =thurifera.
Montezumæ, Humb. et Bonpl. ex Parlatore, l. c. =Taxodium mucronatum.
nepalensis, Loud. Encycl. Trees, 1118. =torulosa.

nivea, hort. =Goveniana.
nucifera, hort. ex Carr. Traité, ed. I. 151. =Glyptostrobus heterophyllus.
nutkanus, Torrey, in Bot. U.S. Expl. Exp. ii. t. 16. =Lawsoniana.
nutkatensis, Hook. Fl. Bor.-Am. ii. 165. =nootkatensis.
orientalis, hort. =sempervirens.
palustris, Salisb. Prodr. 398. =Thyoides.
patula, Pers. Synops. ii. 580. =Thuya orientalis.
patula, Spad. Xilogr. i. 193. =sempervirens.
pendens, F. Muell. Select Pl. Indust. Cult. 64. =obtusa.
pendula, Griffith, Notul. iv. 26. =torulosa.
pendula, L'Hérit. Stirp. Nov. 15, t. 18. =lusitanica.
pendula, Thunb. Fl. Jap. 265. =Thuya orientalis, forma.
pyramidalis, Targ.-Tozz. Oss. Bot. dec. iii.–v. 73. =sempervirens.
Reinwardtii, hort. ex Beissner, Handbuch, 103. =macrocarpa.
religiosa, hort. ex Carr. Traité, ed. II. 144. =lusitanica.
Roylei, Carr. Traité, ed. I. 128. =sempervirens.
sabinoides, H. B. et K. Nov. Gen. et Sp. ii. 3. =Juniperus tetragona.
Schomburgkii, Van Houtte, ex Gord. Pinet. Suppl. 27. =thurifera.
sinensis, Lee, ex Gord. Pinet. 63. =lusitanica.
sinensis, hort. ex Beissner, l. c. 154. =Glyptostrobus heterophyllus.
Skinneri. =Benthami.
sphærocarpa, Parlatore, in Ann. Sc Nat. sér. IV. xiii. (1860) 378. =sempervirens, var.
squarrosa, Laws. ex Gord. Pinet. 296. =pisifera, forma.
stricta, Mill. ex Gord. l. c. 67. =sempervirens.
Tchugatskoy, hort. ex Parlatore, in DC. Prod. xvi. II. 474. =nootkatensis.
tetragona, Humb. et Bonpl. ex Carr. Traité, ed. II. 33. =Juniperus tetragona.
tetragona, hort. ex Gord. Pinet. 71. =thurifera.
tetragona, hort. ex Carr. Traité, ed. II. 155. =lusitanica.
thuiæfolia, Knight & Perry, ex Gord. Pinet. 69. =sempervirens.
thuiæformis, Parker, ex Gord. Pinet. Suppl. 26. =sempervirens.
thuiæoides, Low, ex Gord. l. c. =sempervirens.
thuoides, Pavon, ex Carr. Traité, ed. II. 89. =Libocedrus chilensis.
thurifera, Lindley, Bot. Reg. (1839) Misc. 64. =Benthami, var. Lindleii.
thurifera, Schlechtendal, in Linnæa, xii. (1838) 493. =Benthami.
Thuya, Targ.-Tozz. Oss. Bot. dec. iii.–v. 72. =Thuya orientalis.
thyoides, Pav. ex Gord. Pinet. Suppl. 41. =Libocedrus chilensis.
Tournefortii, Audibert, Cat. (1834), ex Carrière, Traité, ed. I. 115. =sempervirens.
Tournefortii, Tenore, Ind. Sem. Neap. (1852). =torulosa.
triquetra, Loddiges, ex Loud. Hort. Brit. 388. =Tetraclinis articulata.

Tschugatskoyi, hort. =nootkatensis.
Uhdeana, Gordon. =? thurifera.
Uhdeana, Carr. Traité, ed. I. 129. =Benthami, part.
umbilicata, Parlatore, Ind. Sem. Hort. Florent. (1860) 22.
=sempervirens, var.

Sciadophytum sphærococcum, *herb. Mus. Brit.* =Cupressus, sp.

Subgen. CHAMÆCYPARIS (Spach, Gen.).

andelyensis, hort. ex Gord. Pinet. ed. II. 365. =Thyoides, forma.
atrovirens, hort. ex Beissner, Handbuch, 69. =Thyoides, forma.
Boursieri, Carr. Traité, ed. II. 125. =Lawsoniana.
Boursieri, Decaisne, in Bull. Soc. Bot. France, i. (1854) 70.
=Juniperus occidentalis.
brevirumea, Maximowicz, in Bull. Acad. St. Pétersb. x. (1866), 489.
=obtusa.
decussata, hort. ex Carr. Traité, ed. II. 140. =Thuya orientalis, forma.
ericoides, Carr. l. c. 137, 141. =Thuya orientalis.
excelsa, Fisch. ex Carr. l. c. 127. =nootkatensis.
glauca, hort. ex Carr. l. c. ed. I. 141. =Thuya orientalis.
Keteleerii, Standish, ex Parlatore, in DC. Prod. xvi. II. 466.
=obtusa.
kewensis, hort. ex Carr. Traité, ed. I. 133. =Thyoides.
Lawsoniana, Parlatore, in Ann. Mus. Stor. Nat. Firenze, i. (1864), 181.
=Lawsoniana.
leptoclada, Henk. et Hochst. Nadelholz. 257. =Thyoides, forma.
nana, hort. ex Parlatore, in DC. Prod. xvi. II. 464. =Thyoides.
nootkaensis, Carr., *nutkaensis*, Lindl. et Gord., *nutkatensis*, Spach.
=nootkatensis.
obtusa, Sieb. et Zucc. in Endlicher, Synopsis. =obtusa.
pendula, Maximowicz, in Bull. Acad. Pétersb. x. (1866) 489.
=obtusa, var.
pisifera, Sieb. et Zucc. in Endlicher, Synopsis, 64. =pisifera.
pseudo-squarrosa, Parlatore, in DC. Prod. x.i. II. 467.
=Thyoides.
pumila, hort. ex Carr. Traité, ed. II. 124. =Thyoides.
sphæroidea, Spach, Hist. Vég. Phan. xi. 331; *sphæroidalis*.
=Thyoides.
squarrosa, hort. ex Carr. Traité, ed. I. 65. =Thyoides.
squarrosa, Sieb. et Zucc. in Endlicher, Synopsis, 65. =pisifera, forma.
thuiæformis, R. Smith, ex Gord. Pinet. ed. II. 429. =obtusa, var.
thurifera, Endlicher, Synopsis, 62. =? Cupressus thurifera.
variegata, hort. ex Carr. Traité, ed. I. 133. =Thyoides.

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July 8. Price 5s.

THE JOURNAL

OF

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Vol. XXXI. **BOTANY.** No. 217.

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NOTE.—The Charter and Bye-Laws of the Society, as amended to the 19th March, 1891, may be had on application.

RETINOSPORA, genus delendum.

andeleyensis, Carr.	=C. Thyoides, forma.
decurvata, hort.	=Thuia orientalis.
decussata, hort. *fide* Beissner & Hochstetter.	=Thuya orientalis, forma.
dubia, Carr. Traité, ed. II. 141.	=Thuya occidentalis, forma.
Ellwangeriana, hort.	=Thuya occidentalis, forma.
ericoides, hort. ex Beissner.	=Thuya orientalis.
ericoides, Zucc. ex Beissner.	=Cupressus Thyoides.
filicoides, hort.	=Cupressus obtusa, forma.
filifera, Standish ex Gord. Pinet. ed. II. p. 364	=Cupressus pisifera, forma.
flavescens, hort. ex Beissner.	=Thuya orientalis, forma.
glaucescens, Hochst. ex Beissner.	=Thuya occidentalis, forma.
juniperoides, Carrière, Traité, ed. II. 140.	=Thuya orientalis, forma.
Keteleerii, hort. ex Beissner.	=Cupressus obtusa.
leptoclada, hort.	=Cupressus Thyoides, forma.
leptoclada, Zucc. ex Gord.	=C. pisifera, forma squarrosa.
leptoclada, Siebold.	=C. pisifera, forma squarrosa.
lycopodioides, Gordon.	=Cupressus obtusa, forma.
meldensis, hort.	=Thuya orientalis, forma.
monstrosa, hort.	=Cupressus obtusa, forma lycopodioides.
Nobleana, hort. ex Beissner.	=Cupressus obtusa, forma filicoides.
obtusa, Sieb. et Zucc.	=Cupressus obtusa.
pisifera, Sieb. et Zucc.	=Cupressus pisifera.
plumosa, hort.	=Cupressus pisifera.
pseudosquarrosa, hort.	=Thyoides.
rigida, hort.	=Thuya orientalis.
squarrosa, hort. nec Sieb. et Zucc.	=Thuya orientalis, forma.
squarrosa, Sieb. et Zucc. Fl. Jap. ii. 40, t. 123.	=Cupressus pisifera, forma squarrosa.
stricta, hort.	=pisifera, forma.
tetragona aurea, hort.	=Cupressa obtusa, forma.
Troubetzkoyana, hort.	=Cupressus obtusa, forma.

SPECIES INQUIRENDÆ.

Balfouriana, *Lemoine ex Gord. Pinet.* ed. II. 79 (descriptio manca).

Thuya dolabrata, *Linn.*=Thuiopsis dolabrata, *Sieb. et Zucc.* *Cupressum* (*Chamæcyparim*) refert, squamis strobili autem apice clavato-dilatatis nec vere peltatis differt. Inter *Thuiam* et *Cupressum* quodam modo intermedia.

On Assimilatory Inhibition in Plants.

By ALFRED JAMES EWART, B.Sc. (Lond.); 1851 Exhibition Scholar; late Demonstrator of Botany in University College, Liverpool. (Communicated by R. J. HARVEY GIBSON, M.A., F.L.S.)

[Read 21st November, 1895.]

ASSIMILATION, like any other plant function, is liable to be modified by the external conditions under which a plant may happen to be. Thus as regards temperature, there is a minimal, optimal, and maximal point for assimilation, just as there is for respiration, though the optimal, minimal, and maximal points for the two functions do not necessarily coincide. Assimilation may, however, also be modified by internal conditions, about which very little is known. Thus Dehnecke * came to the conclusion, mainly from theoretical deductions, that green, non-assimilating chlorophyll bodies having the function of a leucoplastid, and not of a true chlorophyll body, are of common occurrence in green plants. Similarly Jumelle † found that as the result of subjecting lichens and mosses to dry heat, a condition might be induced in them during which they had lost the power of assimilation, but still continued to respire. Further research in this direction being evidently necessary, I undertook, at the suggestion of Prof. Pfeffer, a series of investigations to determine the various causes by which this condition of what we may term assimilatory inhibition may be produced and the phenomena connected with it.

It was at once evident that the method used by Jumelle was not so well adapted for a research of this kind as is a microscopical method, allowing more rapid observations and more detailed examination of the cells or tissues affected to be made. There are three well established methods by which a microscopical determination of the evolution of Oxygen by green assimilating cells in the presence of light can be made. The first and most important of these is Engelmann's ‡ well-known Bacterium

* Dehnecke, "Ueber nicht assimilirende Chlorophyllkörper." Inaugural-Dissertation, Universität in Bonn (Cöln, 1880).

† Jumelle, "Recherches Physiologiques sur les Lichens," in Revue Générale de Botanique, vol. iv. 1892, pp. 114, 159, 220, & 259.

‡ T. W. Engelmann, "Neue Methode zur Untersuchung der Sauerstoff-ausscheidung pflanzlicher und thierischer Organismen," in Bot. Zeit. Bd. xxxix. (1881) No. 28.

method. The second is the reduced indigo test, first brought into prominence by Regnault and subsequently by Beyerinck *. This method is, however, unsatisfactory, because it requires the presence of a slight excess of sulphuretted hydrogen or $NaHSO_2$ in the reduced indigo solution; and when once the latter has become blue, it can only be reduced again by treatment with fresh SH_2 or $NaHSO_2$. The poisonous action of the sulphuretted hydrogen, and the fact that once the colour returns the experiment ceases, continuous observations being possible only by adding fresh reduced indigo solution, form serious objections to the method. The last objection also applies to the third method, which has indeed found but little practical application, of using the conversion of reduced hæmoglobin into oxyhæmoglobin as a test for the evolution of oxygen.

The advantages of the Bacterium method are that it is much more delicate and easier to observe, the injurious influence of the Bacteria is almost *nil*, continuous observations are possible with the same preparations, and, lastly, the rapidity of the movement and number of moving Bacteria enable a relative estimation to be made of the amount of oxygen evolved, and hence of the intensity of assimilation. Throughout the investigation the Bacterium method was used as a test for the evolution or non-evolution of oxygen. The Bacterium employed was Cohn's *Bacterium Termo* (=*Proteus vulgaris*, Hauser; =*Bacillus liquefaciens vulgaris*, Beyerinck), slope or stab cultures being made on Bouillon-Agar, and allowed to develop at a temperature of 25° C. In actual use the cultures should never be more than 1 to 2 weeks old, and the Bacteria should be taken from the edges of the growth, where it is of more recent formation, and hence consists almost entirely of motile forms.

Great care must always be taken to ensure the absolute purity of the cultures and their entire freedom from anærobic forms. This is readily ascertained by mounting the Bacteria in a drop of sterilized nutrient solution, and, after making certain of the absence of all air-bubbles, ringing the cover-slip with either pure vaseline, or vaseline stiffened with a little wax or paraffin, according to the temperature of the room.

If the culture is a pure one, the movement of the Bacteria ceases as soon as the enclosed dissolved oxygen is exhausted, and if any Bacteria continue to move after having been for one hour

* Beyerinck, in Bot. Zeit. 1890, p. 742.

in a properly ringed and closed cell, then the culture is impure, and anærobic forms, which can move in the absence of oxygen if food material be present, or partial ærobes, such as certain *Spirilla*, which can move in the presence of an infinitesimal trace of oxygen, are present. The *Bacterium Termo* form used, in ordinary tap-water, containing a slight percentage of salts and but a mere trace of nutriment, continues to move as long as oxygen is present, and may remain living and motile in the absence of oxygen for 1 or 2 days, moving as soon as oxygen is admitted or generated. The sensitivity of the Bacteria, however, undergoes, with regard to oxygen, in 12 hours a distinct, and in 24 hours a marked alteration, they becoming less sensitive to the absence and more sensitive to the presence of minute traces of oxygen, *i. e.* partial starvation increases their sensitivity to oxygen. Finally, in the absence of all nutriment, *B. Termo* ceases to move in the presence of oxygen and becomes quite immotile. The maximal and minimal temperatures for movement are widely separated, the optimum temperature lying between 15° C. and 30° C. Above and below these limits the movement is not quite so active, but continues quite actively in the presence of oxygen on the one hand as far as zero, and on the other up to 40° C.

When a cell or tissue is examined by the Bacterium method to detect the presence or absence of the power of assimilating and evolving oxygen, it is naturally important to determine, especially if comparative experiments are to be made, to what extent the evolution of oxygen from the free surface of the cell is modified by the nature of the enclosing cell-membranes or by the surrounding fluid. Is, for example, oxygen evolved more rapidly through uncuticularized than through cuticularized epidermis? To settle this point, isolated hairs of *Gynura aurantiaca* were examined in a closed cell with Bacteria exposed to light. The hair-cells contain a purple dye dissolved in the cell-sap, which fades as the hair grows older, and in the lining plasma rather small and not abundant chlorophyll grains are present. A distinct though not strong evolution of oxygen is shown by all normal chlorophyll-containing hairs, whether the sap is purple or colourless. If the hair has separated exactly at the partition-wall between two cells, it can be seen that the evolution of oxygen takes place with equal activity from all surfaces of the cell. If the torn remains of a basal cell remain attached to the lower end of the hair, the

Bacteria move much more actively inside it, to and fro from the partition wall, than they do elsewhere. This is, however, because a certain amount of nutritious substance is present in such cases, and the Bacteria move more actively in the presence of dissolved nutritious substance and oxygen than in the presence of oxygen in water only. In many cases, on exposure to strong light the chlorophyll grains accumulate for the most part on the partition walls of the hair-cells, and in such separated end cells the evolution of oxygen is naturally more marked from the end wall than from the side walls. Epidermal hairs of *Cucurbita Pepo* and epidermal cells from *Allium* and *Aspidium* gave similar results, the chlorophyll grains being rather more numerous and the evolution of oxygen correspondingly more active. In the young leaves of *Cucurbita*, where the hairs are very abundant and large, the total amount of material assimilated by them must be fairly great, and is most active at a time when the assimilatory powers of the leaf are weak and undeveloped, but when it nevertheless demands stores of plastic material in greatest abundance.

It must be remembered that the conditions for the evolution of oxygen gas from a cell in water are not quite the same as they are in air. In the first case, the gas simply diffuses from a liquid in which it is abundant, through a damp membrane, to a fluid in which it is less abundant; in the second case, it is evolved from the surface of the cell because its partial pressure in solution is greater than in the mixture of gases, *i. e.* the atmosphere, by which the cell is surrounded. In ordinary aerified water, owing to the fact that CO_2 is much more soluble in water than oxygen is, the evolution of the former gas will take place much more rapidly and readily as compared with the rates in air, from a cell in water, than that of the latter gas will. In the closed cell with Bacteria, on the other hand, since the partial pressure in solution of the dissolved CO_2 is very high, whilst that of oxygen is very low, the latter gas will be evolved more rapidly and readily than the former. The difference in the rate at which gas is evolved persists only a very short time after transference from the one medium to the other, and ceases as soon as the amounts of gas dissolved in the cell-sap and permeating the cell are adjusted to their new levels, when the rate at which gas is evolved becomes, provided that the rate of production remains unaltered, the same as it was previously. A living cell or tissue kept in a closed cell-chamber with Bacteria will reach a condition of

equilibrium only when it contains less oxygen and more CO_2 than it normally does, and hence arises the readiness with which prolonged experimentation under these conditions may produce asphyxiation in a non-assimilating tissue.

Heat and Assimilation.

In investigating the effects of heat upon any plant function it is at once necessary to distinguish between dry heat and moist heat, the effects of dry heat being only possible to investigate on plants which can withstand desiccation.

Effects of Desiccation and Dry Heat.

The fact that the majority of seeds and spores can withstand even prolonged drying over sulphuric acid without being markedly affected is well known; and Schröder* has placed on record an exhaustive series of observations upon the resistance which many vegetative plants show to similar desiccation. This resistance is shown by certain Hepatics (*Corsinia*, *Lunularia*, *Marchantia*); but in a more marked degree by certain Mosses (*Barbula muralis*, *Bryum cæspititium*, &c.), Lichens (*Sticta*, *Cladonia*, and *Evernia*), and Protophyceæ (*Nostoc*, *Scenedesmus*, *Hæmatococcus*, &c). Jumelle's experiments also show that many mosses, lichens, &c. must possess considerable powers of resistance to dry heat and desiccation.

After collecting a number of plants of sufficient resistant power to desiccation, a series of preliminary heating experiments with mosses, of which the subjoined table is illustrative, were made. The plants were first air-dried, next dried in a desiccator for a day or two, and then placed in an oven for six hours and kept at a given constant temperature. The plants are then revived in a damp chamber, and leaf preparations from all parts made with Bacteria to test for assimilation, as well as being examined by plasmolysis before or after the presence or absence of assimilation has been ascertained.

The table very clearly shows that six hours' heating is too short an exposure to produce a marked inhibitory after-effect upon the function of assimilation. It is only when the temperature is extremely high that a complete and prolonged inhibition of assimilation is produced, and in such cases the greater number

* Schröder, Bot. Untersuch. Tübingen (Pfeffer), Bd. ii. Heft 1 (1886).

TABLE A.

Des. dried plants for 6 h. at:—	50° C.	60° C.	70° C.	80° C.	90° C.
Grimmia conferta.	All living, and assim. normal.	All leaves living, but assim. weaker than normal. After 1 day in D. Ch. normal assim. returns.	Younger leaves living and assim.; older living leaves assim. very weak. Plants remain living and recover.	Apical leaves living, and in parts show evolⁿ of O. Normal assim. in all living leaves in 1 day.	Yg. leaves and leaf-cells in parts still living, but no assim. & no recovery. A few plants form new sprouts on planting. At 95° C. all plants are killed.
Ceratodon purpureum.	Leaves all living, but evolⁿ of O at first weak or absent.	All leaves living but no assim. After 4 h. in D. Ch. weak evolⁿ of O, in 1 day assim. is of normal activity.	Plants living, but no assim.; normal after 1 day in D. Ch.	Younger leaves living. No assim. In from 1 to 2 days in D. Ch., normal assim. in all living leaves.	Plants all dead, and no recovery.
Bryum cæspititium.	Living, and assim. normal.	Most leaves and leaf-cells living. Rather weak evolⁿ of O, normal after 1 day in D. Ch.	Apical tuft living and showing fairly active assim. In older leaves more or less cells living and plasmolysable, but no assim. After 1 day in D. Ch. all living cells show distinct evolⁿ of O.	Younger leaves all or most cells living. No assim., but in 1–2 days in D. Ch. normal assim. in all living cells. Most plants recover and resume growth.	Plants all dead, and no recovery.
Barbula muralis.	Living, and assim. normal.	Leaves for most parts living, assim. mostly weak, but in 1 day normal.	Younger leaves living, and leaf-bases show fairly active assim.; but outer parts none. In 1 day active assim. in all living leaves.	Few leaves and leaf-bases living, and in some of latter a very faint evolⁿ of O is shown. After 2 days in D. Ch. no assim., though plenty of cells are still living. Plants all finally die.	Plants all dead, and no recovery.
Orthotrichum affine.	Living, and assim. normal.	Leaves all living, but assim. weaker than normal. After 1 day in D. Ch. normal assim. returns.	Younger leaves living and assim.; older living leaves, assim. weak. Remain living and resume growth on planting.	Younger leaves living; assim. in parts fairly active, in parts slight or none. In 1 day all living leaves show normal assim.	Cells in parts of younger leaves living & plasmolysable, but no assim. and no recovery; in a few days all are dead. Heated to 95° C. plants are entirely killed.
Dicranum scoparium.	Living, and assim. normal.	Older leaves dead. Apical leaves living. Weak evolⁿ of O, which in 1 day is normal. Plants recover and resume growth.	Young leaves of apical tuft living, in parts faint evolⁿ of O. Plants do not recover, but on planting slowly die.	All leaves dead.	

N B.—Evolⁿ of O = evolution of Oxygen; assim. = assimilation; D. Ch. = Damp Chamber.

of the leaves are killed; and even those which remain living and show plasmolysis on moistening may have their vitality so injuriously affected that they die without any return of assimilation taking place. One fact may at once be noticed, though it will appear again and again in the future experiments, and that is, that the stoppage of assimilation does not involve any perceptible change whatever in the assimilatory apparatus. Of two cells of precisely similar microscopical appearance, one may be assimilating and the other not.

The table is more of value as showing the extreme resistance which some Mosses show in the dried condition to short periods of heating at high temperatures, than as showing any marked production of assimilatory inhibition. Thus in *Grimmia* and *Orthotrichum* living cells may still be present after heating for 6 hours to 90° C., and may remain living for some days though they have lost all power of assimilation and recovery. In order to obtain the full resistant power of the plants, the air in which they are heated must be perfectly dry. This is well shown by the increased resistant power shown by *Grimmia conferta* under the conditions of the following experiment:—Desiccator dried plants are heated in a $CaCl_2$ desiccator for 6 hours at 95° C.; after moistening, a few of the younger leaves and leaf-cells are found to be living and plasmolysable, but show no assimilation and no recovery. On planting, however, a few plants form new sprouts, *i. e.* under these conditions the plant withstood a temperature 5° C. higher than in the Table A. That the presence of oil has little or nothing to do with the power of resistance to heat is shown by the fact that *Dicranum*, the protoplasm of which contains plenty of oil, is not more resistant, and is in many cases less resistant, than other Mosses in which such oil is absent.

It must be remembered that whenever Assimilation is said to be absent, what is really meant is that under optimal illumination in the presence of CO_2 no evolution of Oxygen can be detected. Assimilation and evolution of Oxygen are not necessarily synonymous, very weak assimilation may be masked by the concomitant respiration. Boussingault * and Holle † state that green leaves in darkness evolve from $\frac{1}{20}$ to $\frac{1}{30}$ the amount of

* Boussingault, 'Agronomie, Chimie Agricole et Physiologie,' vol. iv. 1868, p. 329.

† Holle, in 'Flora,' 1877, pp. 162 and 186.

CO_2 that they can assimilate in the same time under optimal illumination. Hence the possibility of error introduced by using the evolution or non-evolution of oxygen as a test for the presence or absence of assimilation is at ordinary temperatures but slight. Practically, whenever a cell examined by the Bacterium method under optimal illumination shows no evolution of oxygen, the power of assimilation is absent. At high temperatures, however, since respiration, according to Kreusler *, and Bonnier and Mangin †, goes on continually and more and more rapidly, increasing with each rise of temperature, whilst according to Kreusler the assimilatory curve sinks, the possibility of a power of assimilation being present, though no evolution of oxygen can be detected, is much increased. In the following pages all the observations were, with a few exceptions on pp. 386, 387, made at a temperature not above 20° C. In any case, what is certain is that where no evolution of oxygen is taking place, no increase of plastic material can occur, though the waste of substance by respiration may be partially compensated for by weak assimilation. In actual experimentation it has been found that an assimilation and evolution of oxygen, which are imperceptible by the gas analytical method, can be readily detected by the more delicate and discriminatory Bacterium method.

When a preparation is made of a living leaf in which assimilation has been temporarily inhibited, in almost all cases the Bacteria come to rest sooner in the neighbourhood of the leaf than out in the open field. This is because the leaf, though it no longer assimilates, still respires, and the oxygen dissolved in the enclosed water is sooner exhausted in its immediate neighbourhood than it is further away. That such stoppage is not due to the extrusion of mucilage or other substance, exercising a retarding influence upon the movement of the Bacteria, by the leaf, is shown by the fact that the Bacteria move longer in the neighbourhood of a freshly-killed leaf than they do out in the open field.

A normal moss-leaf may remain living and assimilating, in water in a closed chamber with Bacteria, exposed to diffuse daylight for weeks. When, however, assimilation has been temporarily inhibited, the return is slower in a mounted leaf than in

* Kreusler, "Beobachtungen über die Kohlensäure-Aufnahme und -Ausgabe der Pflanzen," in Landw. Jahrb. 1887, Bd. xvi. pp. 711–715.

† Bonnier and Mangin, in Ann. d. Sc. Nat. 7 sér. ii. 1885, p. 378.

one which remains in damp air attached to the parent plant, and in some cases may not take place at all. In water *Bacterium Termo* is to be regarded simply as an absorber of oxygen and producer of CO_2. That in water it exercises no other injurious poisonous influence upon the leaf-cells is shown by the long period of time during which a moss-leaf may remain living in a closed cell with Bacteria. Similarly the shock of removal from the parent plant is so slight as to be negligible. Hence the slower recovery of the separated leaf in a closed cell is due partly to the lack of oxygen, and perhaps partly to deficient nutrition.

The return of assimilation and recovery of the leaf need not necessarily be followed on the same leaf, but can be traced by making successive preparations at given intervals of time from neighbouring leaves. It is the age and position of the leaf which determine its resistant power; each leaf behaves similarly to its immediate neighbours, though between the basal and apical leaves wide differences in behaviour and resistant power may exist. As regards dry heat and desiccation it is the young leaves which are most, and the old leaves least, resistant. As the adult leaves grow older, their resistant power to dry heat, as well as their assimilating powers, becomes lessened.

To obtain good results, it is better to heat for a longer time at a lower temperature. The results of such heating are shown in the columns of Table B, from which several interesting conclusions can be deduced. A comparison between (*a*) and (*b*) and (*c*) and (*d*) shows that strong desiccation previous to heating lowers the plant's resistant powers, but that the drier the atmosphere in which the actual heating takes place the less is the plant affected. Columns *c*, *d*, and *e* show that the duration of the exposure is at least as important as the temperature to which the plant is heated, in producing a prolonged inhibitory after-effect upon assimilation. This after-effect is more readily produced in the older than in the younger leaves. Though it may take days before assimilation becomes quite normal, nevertheless in the young leaves assimilation is rarely completely absent for more than a few hours. Under the same exposure a more prolonged inhibitory after-effect is produced in *Dicranum* than in *Bryum* and *Orthotrichum*.

Table C gives the results obtained with various Chloro- and Cyanophyceæ. The plants are collected as pure as possible, dried in bulk, and then kept in thin flakes on watch-glasses in

the oven at the particular temperature required. They are then moistened, part at once examined, and the rest kept in the damp chamber, and portions examined from time to time. Since when a closed cell preparation with Bacteria is made, the Bacteria do not exhaust the enclosed dissolved oxygen and come to rest for a few minutes, it follows that however rapidly and carefully the preparations are made, sure and certain results are only given a quarter of an hour after the plants have been moistened and the preparations made. If examined before this, the Bacteria may be moving, not because any evolution of oxygen has taken place, but because the oxygen originally present has not yet been exhausted.

The plants in Table C were previously tested to make certain that they could withstand desiccation. After being dried in air at 20° C., and kept in a desiccator for a day or two, they were found all to remain living, and to show at once on moistening an active power of assimilation. Unicellular plants form very good working material, as they are hardly at all affected by manipulation, and each cell can be examined separately. The only precautions necessary are to avoid pressure and excess of either Algal material or Bacteria.

The results obtained are, as regards the inhibition of assimilation, similar to those obtained with Mosses, but the experiments are of especial interest as enabling a comparison to be made between Algal cells when free, and when combined with Fungi to form Lichens.

Table D gives the main results of the experiments with Lichens and with a vascular cryptogam, *Selaginella lepidophylla*. The resistance which the latter plant offers to drying is well known; and Bert and Bureau * mention that it is able to withstand heating to 60° C., the duration of the exposure not being given.

A glance at the table shows that *Selaginella lepidophylla* is markedly affected by a day's heating at 55° C., and is killed after a day (24 hours) at 60° C. For the experiments living branches, the leaves of which showed an active power of assimilation, were cut off, allowed to roll up and become air-dried, and then heated to the required temperature. The first leaves to be affected by

* Bert and Bureau, "Note sur la reviviscence du *Selaginella lepidophylla* et du *Ceterach officinarum*," in Comptes-rendus de la Société de Biologie, 1868.

TABLE B.

	a. Air-dried, and open in oven for 2 days at 50° C.	*b*. Desicc. dried and in Desiccator for 2 days at 50° C.	*c*. Desicc. dried and in Desiccator for 5 days at 50° C.	*d*. Desicc. dried, but open in oven for 5 days at 50° C.	*e*. Desicc. dried and in Desiccator for 2 days at 60° C.
Dicranum scoparium.	Exposed older leaves, no assim., and many cells dead. Younger leaves, all cells living and weak assim. Central leaves of apical tuft assim. almost normal. After 1 day in D. Ch., normal assim. in younger leaves; in 2–3 days, normal in all cases.	Older leaves with rather more dead leaf-cells than in (*a*). Weak assim. in central leaves of apical tuft; in rest of leaves none. In 1 day normal assim. in young leaves, but in older leaves still none. In 2–3 days assim. is shown by all living leaves.	In older leaves many cells are dead, but in young leaves all are living. No assim. In 5–6 h. slight evol^{n} of O, which in 1 day is weak to moderately active. After 2 days many of the older leaves die without assim. returning; but in rest assim is normal.	Very many leaves and leaf-cells killed. No assim. Many plants and all older leaves die, but in the rest the apical tufts remain living, assim. returns, and in 3 days is about normal.	Apical leaves living, and show weak assim. Older leaves plenty of cells living, but no assim. After 1 day in D. Ch. these are mostly still living, but no assim.; in young leaves active assim. After 3 days assim. still quite weak in many leaves. After 5 days all still living leaves show normal assim.
Orthotrichum affine.	Almost all leaf-cells living, but only slight assim., and this mainly in patches; neighbouring parts, all cells of which are living, showing no assim. After 1 day in D. Ch. normal assim. returns.	No perceptible difference from (*a*).	Most leaves and leaf-cells living. No assim. In 1–2 h. in D. Ch. weak assim. in some leaves, in 5–6 h. stronger, and in 2 days normal assim. in all living leaves.	Most leaves and leaf-cells living. At first no assim., in 1–2 h. weak assim. in few leaves; fairly active in 1 day in most cases, and in 2 days normal.	Younger leaves living, assim. very weak. Older leaves, more or less leaf-cells are dead; no assim. In 1 day assim. fairly active in young leaves, weak or absent in rest. In 3 days normal assim. in nearly all living leaves. Many leaves with only patches of living cells finally die without assim. returning, though they may remain living for several days.
Bryum cæspititium.	Few leaf-cells in older leaves dead. Assim. weak or almost imperceptible. After 1 day in D. Ch. normal assim. in all cases.	Rather more leaf-cells dead. Assim. weak or imperceptible. Normal assim. after 1 day in D. Ch.	Many leaf-cells dead, especially in lower older leaves. No assim. In 3–4 h. faint assim. in some leaves, stronger after 1 day. After 2 days in D. Ch, all living leaves show normal assim.		Most leaves and leaf-cells living, but no perceptible assim. In 1 day weak assim., which in 3 days is fairly active. In many leaves no recovery of assim. takes place, though such may remain living for several days.

TABLE C.

	1 day at 40° C.	2 days at 40° C.	1 day at 45° C.	1 day at 50° C.
Scenedesmus acutus.	In ½ h. after moistening very weak evol^n of O; in 1 h. stronger, but still weak; in 2–3 h. about normal.	After 5 h. in D. Ch. still no evol^n of O; distinct but weak in 10 h.; normal in 1 day.	Most cells dead, few living. After 1 day still no assim. In 3 days normal evol^n of O. in all living cells. These were perhaps resting cells.	All cells dead. No recovery.
Pleurococcus, sp.? ...	As in *Scenedesmus.*	Many cells killed; in rest no evol^n of O perceptible till after 1 day in D. Ch.	As in *Scenedesmus.*	All cells dead. No recovery.
Glœocapsa, sp.?......	Weak evol^n of O in ½ h.; in 1–2 h. normal assim. returns.	In ½ h. faint evol^n of O, in 1 h. stronger, and in 2–3 h. about normal.	Many cells killed, but many living. After 8 h. no evol^n of O, but in 1 day evol^n of O about normal.	All cells dead. No recovery.
Rhaphidium polymorphum.	As in *Scenedesmus.*	Only few cells living and these do not show perceptible evol^n of O till after 1 day in D. Ch.	All cells killed. No recovery.	The Algæ on moistening, even if entirely living, do not take up so much water as formerly. This is simply due to a change in the gelatinous substances accompanying such Algæ (*Nostoc*, *Glœocapsa*), and formed by them. The Algal cell and its integral coats swell up to their normal size, and absorb as much water as formerly, after an hour or two if living.
Merispomœdia, sp.?	As in *Glœocapsa.*	In ½ h. faint evol^n of O, in 2 h. moderately active, and in 3–4 h. about normal.	All cells killed. No recovery.	
Nostoc, sp.?	Very weak evol^n of O in ½ h.; in 1 h. still weak; in 2–3 h. about normal.	After ½ h. still no assim., weak in 1 h., and in 3–4 h. about normal.	All cells killed. No recovery.	

Table D.

	1 day at 45° C.	2 days at 45° C.	3 days at 45° C.	1 day at 50° C.	2 days at 50° C.	1 day at 55° C.
Selaginella lepidophylla.	Leaves all living and Chl. grains normal. After 1 h. no evol^n of O; in 2 h. weak, in 4 h. moderately active, and in 8 h. normal evol^n of O.	After 2 h. no evol^n of O. In 4 h. weak, and in 8 h. about normal assim.	Most leaves living. After 4 h. no evol^n of O, in 8 h. weak, and in 1 day fairly active.	Many leaves killed, most living. After 4 h. no evol^n of O. After 8 h. in D. Ch. weak in few leaves; after 1 day in all living leaves, and active in same. In 3 days fairly active assim. in all living leaves.	Very few leaves living, but show no assim. and no recovery, though the leaves may remain living in D. Ch. for from 1–2 days.	Plenty of living leaves. After 8 h. very weak evol^n of O in few cases. After 1 day weak evol^n of O from most living leaves, in parts active. After 3 days moderately active in all living leaves. ——— 60° C. for 1 day. All leaves killed. No recovery.
Evernia Prunastri.	Gonidia mostly living; few parts show weak evol^n of O, mostly none. In 4 h. moderately active assim.; in 8 h. quite active.	No evol^n of O, after 4 h.; in 8 h. faint traces in younger branches; in 1 day weak, and in 3 days fairly active. Most gonidia are killed, and after 1 week greater part of Lichen is seen to be dead, but in parts the gonidia are living, multiplying, and actively assimilating.	Nearly all plants killed. No evol^n of O after 8 h. In 1 day in few young branches, more or less gonidia living and weak evol^n of O; in 3 days moderately active; and in 1 week these branches are quite regenerated, and show quite active evol^n of O.	After 8 h. no evol^n of O, weak in a few cases in 1 day. In 3 days greater part of Lichen is seen to be dead, but in few branches gonidia are living and show fairly active evol^n of O. After 10 days these branches are living and normal.	Plants all killed. No recovery.	Plants all killed. No recovery.

Cladonia rangiferina.	Gonidia all living, but at first only in a few parts is a weak evol^n of O shown, mostly none. In 4 h. assim. is active in all cases.	No. evol^n of O; in 4 h. feeble evol^n of O from many younger branches. In 8 h. feeble evol^n of O from most parts; in a few young branches moderately active. In 1 day assim. is normal. Practically all gonidia remain living.	No evol^n of O. After 8 h. weak in few cases, mostly none. In 1 day mostly weak evol^n of O; in parts none, and in parts moderately active. In 3 days active evol^n of O in most part, but in a few older branches evol^n of O is still weak, and here more or less gonidia are dead.	After 2 h. no evol^n of O; in 8 h. weak in few cases. In 1 day fairly active assim. in most cases; in few still weak. In 3 days assim. quite active, practically all gonidia remain living.	In 4 h. no evol^n of O. In 8 h. faint traces, or in few cases weak evol^n of O. In 1 day moderately active evol^n of O for most part, in many cases still weak or absent. In 3 days active evol^n of O in almost all parts.	In 8 h. faint traces of assim. in few younger branches. In 1 day weak evol^n of O, and in some younger branches moderately active. In 3 days mostly moderately active evol^n of O; in parts quite active. A good many gonidia have been killed, and in some parts all.
Cladonia rangiferina.	1 day at 60° C. In 8 h. faint traces of assim. in few younger branches. In 1 day mostly weak evol^n of O, moderately active in many younger branches. In 3 days mostly moderately active evol^n of O, and in parts quite active. Many of older plants and branches, all gonidia killed, and no recovery. The gonidia are sooner affected, and are less resistant when thinly scattered than when in large clumps.		1 day at 65° C. No evol^n of O after 1 day. After 3 days in D. Ch., most plant, all gonidia, dead, and fungal part also shows signs of death. Few plants with more or less living clumps of gonidia; these remain greenish, rest of lichen turns quite white. Such parts show weak or moderately active evol^n of O; the gonidia are proliferating and masking the dead cells. In a week the clumps are larger, and many show quite active evol^n of O; but only few plants, or parts, are regenerated in this way *.		1 day at 70° C. Plants all killed, both Fungus and Alga; and no recovery.	

* It is possible that here the gonidia which survived were in a resistant resisting stage, the vegetative gonidia being all killed, and an evolution of oxygen being only perceptible when the former had begun to proliferate and multiply.

For purposes of comparison the following table is appended, giving the results of heating the same plants in the moist condition, which at once shows how enormously the presence of water lowers the resistant power to heat of a plant which is capable of withstanding desiccation.

TABLE E.

	1 day at 35° C.	1 day at 40° C.	1 day at 45° C.
Cladonia rangiferina	Most gonidia living. Weak evol^{n} of O, which in 1 h. is moderately, and in 3 h. quite active.	Gonidia living in parts only. No evol^{n} of O. In 1 h. at 20° C. weak, and in 3 h. moderately active.	All gonidia killed.
Evernia Prunastri / *Parmelia parietina*	As in *Cladonia*.	All gonidia killed.	
Selaginella helvetica	All leaves living, and show active evol^{n} of O.	Nearly all leaves living. No evol^{n} of O; fairly active in $\frac{1}{4}$ h., quite in $\frac{1}{2}$ h., at 20° C.	Most leaves living. No evol^{n} of O after 1 h., weak in 3 h., active in 5.
	In *Selaginella*, after 1 day at 50° C., all leaves are killed.		

heating are the outer ventral leaves; the inner dorsal leaves, being shielded to a certain extent by the inrolling of the dried branches, resist longer. The leaves of *Selaginella* always contain a little air, hence the preparations must be kept in darkness when first made until the Bacteria cease to move, then exposed to light and examined.

The Lichens are examined by means of thin sections, in which the assimilating activity of the gonidial cells can be determined without the Fungal respiration being able to exercise any disturbing influence. Bearing the greater delicacy and discriminating powers of the Bacterium method in mind, it is not surprising to find that by its help an assimilation and consequent evolution of oxygen can be detected in cases and under conditions in which, according to Jumelle, no such evolution of oxygen should have been perceptible.

Thus Jumelle mentions that in plants of *Cladonia rangiferina* kept air-dried for three months and then moistened and examined, respiration was much weakened, and assimilation had almost entirely disappeared. Plants of *Cladonia rangiferina* and *Evernia Prunastri*, however, after being kept air-dried in wide open-mouthed bottles in darkness at 15° C. to 20° C., were for the most part living. On moistening, at first no perceptible or a mere trace of assimilation was shown, but after half an hour a moderately active, and after one hour a quite active evolution of oxygen is shown by the gonidia.

As Jumelle does not state under what conditions his air-drying experiments were conducted, it is impossible to be certain whether or not other factors beyond the air-drying came into play in his experiments. Thus the temperature at which the air-dried plants are kept is a very important factor, and air-dried plants exposed to sunlight are much more rapidly injuriously affected than similar plants kept in darkness.

In addition to this, the resistance which the plants offer to drying is largely dependent upon their vegetative vigour when collected.

The plants of *Cladonia* experimented with in Table D were quite young and healthy, but the plants of *Evernia* were not nearly so vigorous. A few additional experiments made with some normally vigorous plants of *Evernia*, which were collected after the table had been completed, showed that with these more healthy and more resistant specimens an increased temperature

of nearly 5° C. was needed to produce the same results as previously.

For purposes of comparison a few of Jumelle's results with dry heat are here given :—

At 40° C.—*Evernia Prunastri.* After 1 day still assimilated; after 2 days gave off more CO_2 than it absorbed; after 3 days respired only.

" " *Glœocapsa* and *Palmoglœa.* After 1 day assimilation is but little greater than respiration; after 2 days all power of assimilation is lost.

At 45° C.—*Dicranum scoparium* after 1 day gives off CO_2 and absorbs O in sunlight.

" " *Glœocapsa* and *Trentepohlia* after 1 day respire only.

At 50° C.—*Evernia Prunastri.* After 1 hour still assimilates; after 3 hours respiration is stronger than assimilation; after 14 hours respires only.

" " *Cladonia rangiferina.* After 5 hours assimilation is still stronger than respiration, after 14 hours gives off CO_2 in sunlight.

At 55° C.—After 1 hour Lichens give off CO_2 in sunlight; but after 7 days *Cladonia rangiferina* still respires, though with but $\frac{1}{5}$ to $\frac{1}{10}$ its pristine vigour.

" " *Orthotrichum affine* after 7 days showed almost normal assimilation.

At 60° C.—*Evernia Prunastri* after 9 hours still respired.

On comparing these results with those given in the four preceding tables, it will at once be seen that the temperatures mentioned by Jumelle as necessary to produce the results given are, except with *Orthotrichum* and *Glœocapsa*, where the results obtained coincide fairly well, much too low. This discrepancy does not indicate any lack of accuracy in Jumelle's observations, but simply emphasizes the fact that the gas-analytical method is not so delicate and discriminatory as the Bacterium method is.

Thus in *Dicranum* a power of assimilation is still present long after it should, according to Jumelle, have ceased. In the leaves of the apical tuft of this plant, owing to the relative difficulty with which gases will diffuse to and fro from the inner and more protected leaves, and to the shading from the light of the inner

leaves by the outer, a power of active assimilation may be present in the inner leaves and be readily detected by the Bacterium method, though none can be detected by the gas-analytical method. It is impossible by the latter method to make any allowance for the fact that commonly the different parts of the same plant may be differently affected by the same exposure. Thus in the young leaves, after a given exposure, a power of assimilation may still be present, but in older leaves absent, whilst in the oldest leaves many or all of the cells may be killed. As seen above, such a plant by the gas-analytical method appears to have no perceptible power of assimilation.

In the case of Lichens the error is still more increased by the fact that here the assimilation has to act against the respiration of both Fungus and Alga, and that the assimilating cells are normally more or less shaded from light by the fungal hyphæ with which they are surrounded or covered. The substance of a Lichen is always rather opaque, and even where the gonidia are on the outside of the thallus, the inner gonidia are largely shielded from light which falls on the outside of the thallus. Jumelle *, as the result of his experiments upon the assimilation of Lichens, concludes that there is no maximum or optimum intensity of illumination for assimilation in Lichens, but that sunlight is always better than diffuse daylight. The explanation of this, however, may be that even when exposed to direct sunlight the Algal cells in an intact Lichen are for the most part exposed to an intensity of illumination not greater than that of bright diffuse daylight. With crustaceous Lichens, Jumelle finds that it is only when exposed to direct sunlight that they give off more oxygen than CO_2, the result being probably partly due to the opacity of the Lichen, and by no means indicating that the gonidia only assimilate actively when exposed to intense light.

When examined in the form of thin sections, it is found that with increasing intensity of illumination beyond bright diffuse daylight no further increase in the rapidity of the evolution of oxygen takes place. The assimilation of the algal cells, whether free or combined, in a Lichen remains the same, provided the other external conditions are alike. The amount of oxygen given off by any Lichen when assimilating is dependent upon

* Jumelle, "L'Assimilation chez les Lichens," in Comptes Rendus, Paris, t. cxii. 1890.

(1) the relative number and nature of the gonidia and the intensity of light to which *they* are exposed; (2) the proportionate amount and respiratory activity of the fungal component; (3) the respiratory activity of the algal cells themselves. In testing a Lichen for its assimilating powers by the Bacterium method, (2) is eliminated, and it is possible to be always certain that the algal cells are optimally illuminated.

It is not easy to understand why with equally vigorous plants the resistance of the gonidia of *Cladonia* to dry heat should be so much more pronounced than those of *Evernia.* The algal cells in both are extremely alike, being a similar Protococcus form. In *Cladonia* the gonidia are scattered or in clumps, interwoven with loose hyphæ on the outside of the thallus, the thick clear hyaline layer of closely packed hyphæ being internal. In *Evernia* the latter layer is external and the gonidia form a dense layer immediately beneath it and are also scattered through the central loose hyphal network. The gonidia in the latter case are therefore better protected from desiccation than they are in the former, but are nevertheless less resistant. The explanation may be that the more exposed position of the apparently similar gonidia of *Cladonia* has caused them to become by adaptive modification more resistant to desiccation, and this to such an extent as to more than counterbalance their greater exposure.

To determine the resistance of the Fungal component is not at all easy. It is extremely difficult to say on immediate examination whether the Fungal hyphæ are dead or living. To plasmolytic methods they do not answer, and microscopical examination commonly fails at first to detect any perceptible difference between dead and living hyphæ, even where these are loosely woven as in the medulla. After being kept for several days in a damp chamber, the hyphæ of a dead plant begin to show various disintegratory changes, saphrophytic fungi begin to appear, the gonidia bleach, and the plants become much less water-absorbent, even in a damp atmosphere being more or less shrivelled. It is, however, always possible that in such cases the Fungal component was originally living, its death following only as a result of the death of the Algal component.

An exposure which kills all the gonidia seems also sufficient to destroy the vitality of the Fungus, for such plants if fed with sugar

solution show no signs of life *; and even if sprinkled repeatedly with water containing living Protococci obtained from specimens of the same Lichen, no regeneration and reorganization of the Lichen takes place as might be expected to occur if the fungal hyphæ were living. On the other hand when, as in many cases, the gonidia remain living only over a part of the thallus, such parts remain living and normal in appearance however long they may be kept under observation. Also in such areas many of the gonidia may be killed, only a portion remaining living; and when this is the case after a few days to a week or more in such regions a multiplication and regeneration of the gonidia take place, the dead algal cells becoming less and less numerous as the living ones multiply.

Hence whenever the gonidia remain living, the Fungus remains living also, the Algal component being apparently the first to be killed. The conclusion, therefore, is that the resistant power of the Fungal component to desiccation and dry heat is slightly higher than that of the Algal component, but that the difference is very slight, it being impossible by drying or heating to entirely kill the one without also killing the other.

It is worthy of notice in this connection that the combination of Alga with Fungus seems to increase the resistant power of the former (compare tables C & D). Whether this is (*a*) a temporary modification due to the symbiosis, or (*b*) a merely mechanical protective effect of the enclosing fungal hyphæ, or (*c*) a special permanent modification induced by natural selection, is difficult to say. That (*b*) exercises some influence is certain, and that (*a*) is of some importance is rendered probable by the fact that the symbiotic condition does in many cases induce a change in the structure of the Alga, such as the breaking-up of chains of cells and the thickening of the cell-wall, which latter would readily account for an increased resistant power. Whether such temporary modification due to the environment can be rendered permanent by natural selection is an open question. In the case of the Fungal component a permanent modification, selective or acquired, one indication of which is the increased thickness of the hyphal cell-walls, fitting it for a dry habitat, has certainly

* A. Möller ('Ueber die Cultur flechtenbildender Ascomyceten ohne Algen,' Münster, 1887) has shown that it is possible to grow and develop in suitable media the isolated Fungal components of Lichens.

taken place, for the vegetative mycelia of ordinary fungi are readily killed by drying.

Certain of the conclusions which Jumelle draws from his experiments on the effects of dry heat on assimilation cannot be passed over without criticism. He concludes that (*a*) heating alters chlorophyll whether the cell contains water or not, but that the protoplasm remains uninjured for a much longer period, and here the presence or absence of water is an important factor; (*b*) the stoppage of assimilation is a permanent one and is due to a destruction of the chlorophyll, the protoplasm remaining living and capable of respiration; (*c*) it is owing to this ready decomposition and destruction of the chlorophyll that lower green plants, although often capable of drying, offer little more resistance to dry heat than higher plants do; (*d*) chlorophyll is destroyed by heat before protoplasm is; (*e*) non-chlorophyllous plants are those which offer the greatest resistance to heat, and hence he concludes that the Alga in a Lichen is killed long before the Fungus is, which does not appear to be the case.

The stoppage of assimilation produced by dry heat is not necessarily a permanent one and is never accompanied by any visible alteration in the colour, form, shape, or condition of the chlorophyll bodies so long as the cell remains living, though of course it is always possible that an invisible alteration may occur. The presence or absence of water is of just as much importance in the preservation of the vitality of the chlorophyll grain as in that of the protoplasm. The presence or absence of chlorophyll has little or nothing to do with the resistant power of plants to dry heat. Non-chlorophyllous plants are not necessarily more resistant to dry heat than chlorophyllaceous plants. It is doubtful whether any plants, chlorophyllous or non-chlorophyllous are, in the vegetative condition, more resistant to heat than the mosses in the experiments given in Table A. Chlorophyll is certainly not destroyed by heat before protoplasm is. In certain cases, it is true, a cell may remain living for a few hours or even days without the power of assimilation returning, but microscopical examination fails to detect any change in the assimilatory apparatus until the death of the cell takes places.

It is very possible that both the duration and degree of the desiccation to which the plants are submitted are of importance in inducing the inhibitory after-effect upon assimilation. The preceding tables show the importance of the first factor, and that of

the second appears to be shown by the following data:—The upper leafy portions of the stems of *Dicranum scoparium* are kept air-dried for 3 months at 18° C. to 20° C. The leaves and leaf-cells are for the most part living, and on making cell-preparations with Bacteria show as soon as examined an active evolution of oxygen, *i. e.*, the absorption of water is almost immediately followed by a resumption of assimilation even after so long a dormant period. A sample of such dried plants contained 8·18 per cent. of water (calculated by keeping a known weight in a $CaCl_2$ desiccator at 100° C. to 105° C. till no further loss of weight takes place). After drying in desiccator for several days, until the weight shows no further appreciable diminution, the plants still contained 1·78 per cent. of water.

Another sample of fresh plants contained 53·7 per cent.; after being air-dried for a few days contained 15·88 per cent.; after being in a desiccator at 35° C. till the weight remained constant, contained 2·07 per cent. of water.

Plants of *Cladonia rangiferina* kept air-dried for 3 months at 15° C. to 20° C. are almost unaffected, the gonidia being almost all living. If moistened and rapidly examined, at first no perceptible or a mere trace of an evolution of oxygen is shown, but this after ½ hour is moderately active and in 1 hour is quite active. The plants contained 14·55 per cent. of water; after being kept for 1 day at 45° C. they contained 6·9 per cent., after 2 days 6·84 per cent., after 3 days 6·76 per cent., and after a 4th day at 50° C. 5·56 per cent.

On comparing these results with those in Table D, it can at once be seen that there is a distinct relation between the degree of desiccation and the inhibitory after-effect produced upon assimilation. The relation between the two is, however, by no means proportional, and whether it is causal or merely accidental it is impossible to say.

Effects of Moist Heat.

It is well known that at a certain maximal temperature a chlorophyllous cell or tissue ceases to assimilate. Thus with *Aspidium*, *Mimosa*, *Chara*, *Elodea*, and various Mosses at a temperature of from 37° C. to 39° C., though exposed to optimal illumination, no evolution of oxygen can be detected by the Bacterium method. It is of course always possible that assimilation may continue at temperatures considerably above those at which any evolution of

oxygen ceases to be perceptible, the latter being overpowered by the increased respiration before assimilation actually ceases. Thus Kreusler * found that assimilation begins to decrease at 30° C., at 45° C. is not entirely stopped, and at 50° C. is imperceptible (*Rubus* and *Ricinus*). The stoppage of assimilation is here a direct effect of the temperature to which the plants are exposed. To produce a stoppage of assimilation as an after-effect of the exposure, and persisting after the exposure has ceased, is by no means easy. If the exposure is severe the plant may be fatally injured and not recover at all; if less severe, it may be either unaffected or recover almost immediately. This is shown in Table F. The plants were exposed for 1 day at the temperature given, and after examination at the same temperature, brought to a temperature of 18° C. and kept under continuous observation.

TABLE F.

	At 31° C. to 32° C.	At 36° C. to 37° C.
Chara fragilis.	Rotat[n] rapid. Evol[n] of O very weak, in ¼ h. at 18° C. mod. active, in ½ h. quite active. Rotat[n] slightly slower.	Rotat[n] slightly slowed. No evol[n] of O. In ¼ h. at 18° C. weak, in ½ h. mod., and in 1 h. quite active and rotat[n] normal.
Elodea canadensis	Very weak evol[n] of O. Few cells slow rotat[n] ¼ h. at 18° C., rotat[n] active, evol[n] of O mod. active, and in ½ h. quite active.	No evol[n] of O or rotat[n]. In ¼ h. at 18° C. rotat[n] active, no evoln. of O, but in ½ h. weak and in 1–2 hrs. active.
Selaginella helvetica. *Oxalis Acetosella.* *Cystopteris fragilis.* *Metzgeria furcata.*	Very weak evol[n] of O, in ¼ h. to ½ h. at 18° C. mod. active, and in 1 h. quite active.	No evol[n] of O, in ¼ h. weak, in ½ h. mod. active, and in 1–2 hrs. quite active.
Orthotrichum affine. *Parmelia parietina.* *Dicranum scoparium.*	Weak evol[n] of O, fairly active in ¼ h. at 18° C., quite in ½ h.	No evol[n] of O, weak in ¼ h., mod. active in 1 h., and quite in 2 hrs.
Bryum cæspititium ...	Rather weak evol[n] of O, quite active in ¼ h. at 18° C.	No evol[n] of O, weak in ¼ h. at 18° C., mod. active in ½ h., quite in 1 h.

Table G shows that plants kept at 37° C. to 38° C. for 3 days, if kept moist and well supplied with oxygen, are all living, and almost no inhibitory after-effect upon assimilation has been produced.

* Kreusler, "Beobachtungen über die Kohlensäure-Aufnahme und -Ausgabe der Pflanzen," in Landw. Jahrb. 1887, Bd. xvi. pp. 711–715.

TABLE G.

Selaginella helvetica.	No evolution of O at 38° C., weak in ¼ h. at 20° C., fairly active in ½ h., quite in 1 h.
Oxalis Acetosella.	No evolution of O at 38° C., weak in ½ h. at 20° C., moderately active in 1 h., quite active in 2 hrs.
Chara fragilis.	Slow creeping rotation, which in 5 minutes is fairly active. No evolution of O at 38° C., weak in ¼ h. at 20° C., active in 1 h.
Elodea canadensis.	No rotation, slow in 5 minutes and in 15 minutes fairly active. No evolution of O at 38° C., weak in ¼ h., quite active in 1 h.

If, however, plants are kept at a raised temperature in a limited supply of air for some time, a stoppage of assimilation, persisting for some time after the plant has been brought under normal conditions, may be fairly readily induced. The effect is really due to the plants being subjected to partial asphyxiation, and is more readily produced in Phanerogams than in Mosses, owing to the former plants being more sensitive to asphyxiation than the latter are. The results of heating under such conditions are shown in Table H, the young plants being kept in pots under closed bell-jars for a day at 37° C. to 38° C., examined at the

TABLE H.

Helianthus annuus. *Cucurbita Pepo.* *Vicia Faba.* *Ricinus communis.*	No evolution of O. After 1 h. at 20° C. still none. After 3 hrs. weak, in 6 hrs. fairly active, and in 1 day quite active.
Zea Mays. *Aspidium violascens.*	No evolution of O, weak in 2 hrs., fairly active in 4, quite active in 1 day.
Phaseolus vulgaris ...	No evolution of O. Stems and undeveloped leaves only remain living. The former show after 1 day a distinct evolution of O.
Lupinus albus	Cotyledonary and young undeveloped foliage leaves living. Protoplasm in many of cotyledonary cells aggregated in 3 to 6 spherical masses; when these fuse together, the cell is again plasmolysable. Chlorophyll grains normal, but frequently massed together. No evolution of O, none after 5 hrs., weak in 10 hrs., and in 1 day fairly active.

same temperature, and then brought to 20° C. and kept under continuous observation.

In the first six plants all the leaves remain living and recover. In both *Lupinus* and *Phaseolus* the foliage leaves, which after a day or so at 20° C. are entirely dead, contained at first many plasmolysable cells with normal chlorophyll grains. These cells show no evolution of oxygen and do not recover, having permanently lost the power of assimilation.

A prolonged stoppage of assimilation produced as a result of moist heat alone can only be brought about when the temperature to which the plant is heated approaches dangerously near to its critical point (Table I). The plants were heated in darkness with a relatively abundant supply of moist air.

TABLE I.

	1 day at 40° C.	1 day at 45° C.
Cladonia rangiferina.	Gonidia mostly living. No evolution of O. In 1 h. at 20° C. weak evolution of O, which in 3 hours is moderately active.	Dead.
Oxalis Acetosella.	Most leaves living, few with brownish dead patches. Both no evolution of O, in 2 hrs. moderately active in former, in latter still weak after 5 hrs., moderately active in 1 day.	"
Dicranum scoparium.	Plenty of living leaves; chl. grains normal, but protoplasm somewhat attenuated. No evolution of O, after 1 day still imperceptible, in 2 days weak, and in 5 days active from all still living cells.	"
Bryum cæspititium.	Most leaves living. After 8 hours no evolution of O, in 1 day weak and in 2–3 days active in all living cells. As in *Dicranum*, many cells die without assimilation returning, but most plants recover.	"
Selaginella helvetica.	No evolution of O, fairly active in ¼ to ½ h. at 20° C., quite in ½ to 1 h. Almost all leaves and leaf-cells living.	Most leaves living. No evolution of O, weak in 3 hrs., fairly active in parts in 5 hrs., in many still weak. In 1 day evolution of O normal.

Cold and Assimilation.

The lowest temperature at which determinations can be made by the Bacterium method is just above zero at about 1° C. In all cases, unless otherwise mentioned, the frozen plants are thawed and examined at this temperature and then brought to a temperature of from 15° to 20° C. The following plants taken during January after 3 weeks continuous frost, the temperature often falling below −15° C., showed when examined no power of assimilation, though most of the leaves remained living:—*Ilex Aquifolium, Buxus sempervirens* var. *arborescens, Pinus montana, Taxus baccata, Thuja occidentalis, Juniperus Sabina, Cheiranthus Cheiri, Ulex europæus, Cytisus austriacus.* After 2 to 4 hours at 15° C. weak assimilation, in parts moderately active, is shown, and in from 8 hours to 1 day assimilation is quite active. A long latent period of recovery indicates that the exposure has very nearly reached the plant's limit of resistance.

Many herbaceous plants are able, if covered by snow, to retain last year's leaves alive and green during the entire winter. A series of such plants were examined in the middle of winter after having been covered by from 1 to 2 feet of snow for 4 weeks, when in all cases at first no assimilation was shown, weak to moderately active after 3–5 hours at 15° C., and quite active in 1 day:—*Primula marginata, Helleborus lividus* and *H. guttatus, Poa pratensis, Catharinea undulata, Ceratodon purpureum, Hypnum triquetrum, Secale cereale, Triticum sativum, Opuntia Rafinesquii.* Certain herbaceous plants are able to withstand prolonged and severe exposure without being markedly affected. Thus the leaves of flowering plants of *Crocus,* after being kept frozen for a week at from −2° C. to −5° C., showed on examination fairly active assimilation. After further exposure for 3 days to −5° C. to −12° C. they remained living, showed at first no assimilation, but after 1–2 hours at 15° C. weak, in 3 hours fairly, and in 5 hours quite active assimilation. Similarly, plants of *Sempervivum Braunii,* after being exposed for 3 weeks to a temperature varying from −5° C. to −15° C. were living but showed no assimilation, none after 3 hours at 15° C., faint in 5 hours, and fairly active in 1 day.

The stoppage of assimilation caused by exposure to cold is not necessarily accompanied by any visible change in either chlorophyll or protoplasm, though changes may in certain cases be

produced in the colour of the chlorophyll grains by prolonged and severe exposure. This brown or yellow coloration commonly shown by Conifers, *Buxus*, &c. during winter has been most thoroughly investigated by Schimper, who finds that the brown coloration is due to a modification of the chlorophyll pigment caused by the combined effect of exposure to cold and light. In certain cases a yellow coloration is produced, the chlorophyll grains being quite pale or faintly yellowish. This, according to Haberlandt, is due to the light decomposing the chlorophyll and the low temperature preventing its re-formation. Schimper finds that the change of colour is due solely to a modification of the chlorophyll pigment, and is not accompanied by any destruction or disintegration of the chlorophyll bodies. Mechanical influences, pressure, section-cutting, or intense frost may cause the chlorophyll grains to disintegrate, but all such cells soon die and cease to be plasmolysable. One result of prolonged severe exposure to cold is to make the chlorophyll grains very liable to be disrupted and disintegrated. A chlorophyllous cell, which has been browned or turned yellow by the action of cold, can only become green again if the chlorophyll grains remain intact.

Browned specimens of *Buxus*, *Juniperus*, *Taxus*, *Abies*, and *Biota* became green again after being kept in a greenhouse at 10° C. to 15° C. for from 3 to 5 weeks.

None of the browned parts showed any perceptible power of assimilation even after being for several days in a greenhouse, but any parts with green and normal chlorophyll grains showed in from a few hours to a day a distinct power of assimilation. In deeply-browned specimens of *Juniperus communis* a weak evolution of oxygen can be detected as soon as the leaves begin to turn green, and a fairly active evolution of oxygen may be shown in leaves in which a slight trace of the brown colour is still perceptible. Pale yellow branches of *Thuja orientalis* begin to turn green in 3 weeks. After 4 weeks plenty of branches are still quite pale yellow and show no evolution of oxygen, but others though pale are distinctly green and show a weak power of assimilation. After 5 weeks fairly active assimilation is shown by leaves which are still slightly yellowish, and the chlorophyll grains, though green, paler than normal.

If the exposure inducing browning be too severe and prolonged the power of recovery is lost, but otherwise, provided the

chlorophyll grains remain uninjured and intact, the re-formation of the green pigment soon takes place, and this occurs more rapidly in entire plants than in experiments as above with isolated branches. As might be expected, the return of assimilation is coincident with the re-formation of the chlorophyll, and begins before the formation of the latter is complete. In many plants, however prolonged the exposure may be, no change of colour is produced in the chlorophyll so long as the cells remain living. Thus in *Ulex* and *Ilex*, at the end of winter all the exposed leaves or spines were brown, but the browning is here a post-mortem change and is a sign of death. It frequently happens that the different parts or even different layers of the same leaf may be differently affected. Thus in *Buxus*, at the end of winter many leaves have in the middle mesophyll layers normal green chlorophyll grains and show a distinct power of assimilation, those of the upper layer of palisade parenchyma being quite brown and showing no power of assimilation, whilst the cells of the lower spongy mesophyll, forming about one-third the thickness of the leaf, are all dead and shrunken. Such leaves in spring soon die and drop off. In most leaves the upper outer layers of the palisade parenchyma contain brown or greenish-brown chlorophyll grains, and show none or only very faint power of assimilation, whilst the less exposed tissue on the underside of the leaf has distinctly green chlorophyll grains and shows a fairly active power of assimilation.

In order to compare the effect of prolonged exposure upon the subsequent powers of respiration of the plant with that upon assimilation, a few experiments, the results of which are given on pp. 392–393 were performed. The CO_2 given off is absorbed by KHO, the decrease in the volume of air contained in the receiver giving approximately the amount of CO_2 evolved. The readings are taken at the same temperature and pressure throughout, and the experiments are continued until the vitality of the specimens begins to diminish and the amount of CO_2 evolved to decrease.

I. *Ulex europæus.*—Living green branches showed at first no perceptible evolution of Oxygen but in 3 hours at 15° C. weak and in 8 hours fairly active.

5 grammes green branches.				5 grammes similar green branches.			
Reading.	Time.	CO_2 evolved per 30 min.		Reading.	Time.	CO_2 evolved per 30 min.	
182 c.c.	9.30 A.M.			181 c.c.	9.30 A.M.		
180·5 c.c.	12 „	0·3 c.c.	Light.	178·8 c.c.	12 „	0·44 c.c.	Darkness.
178·5 c.c.	2.30 P.M.	0·4 c.c.	Darkness.	176·3 c.c.	2.30 P.M.	0·50 c.c.	Darkness.
178·1 c.c.	5 „	0·08 c.c.	Light.	173·9 c.c.	5 „	0·48 c.c.	Darkness.
	Next day.				Next day.		
157·7 c.c.	10 A.M.	1·2 c.c.	Darkness.	161·5 c.c.	10 A.M.	0·73 c.c.	Darkness.
157·5 c.c.	10.30 „	0·2 c.c.	Light.	161·3 c.c.	10.30 „	0·2 c.c.	Light.
157·5 c.c.	3 P.M.	0·0 c.c.	Light.	161·3 c.c.	3 P.M.	0·0 c.c.	Light.
156·5 c.c.	5 „	0·25 c.c.	Darkness.	160·5 c.c.	5 „	0·2 c.c.	Darkness.

II. *Thuja Standishii.*—Specimens taken after temperature had been at from −8° C. (day) to −15° C. (night) for several days, showed after 3 hours at 18° C. no power of assimilation, but after 5 hours weak and in 1 day fairly active assimilation in all cells with normal green or only slightly browned chlorophyll grains. All cells with quite brown chlorophyll grains, which are mostly in the outer layers of the leaf, show after 1 day still no assimilation.

8 grammes quite brown twigs.			8 grammes green or very faintly browned twigs.		
Reading.	Time.	CO_2 evolved per ½ hour.	Reading.	Time.	CO_2 evolved per ½ hour.
181·5 c.c.	3.30 P.M.	In darkness.	180·0 c.c.	3.30 P.M.	In darkness.
181·0 c.c.	4 „	0·5 c.c.	178·7 c.c.	4 „	1·3 c.c.
180·7 c.c.	4.30 „	0·3 c.c.	178·1 c.c.	4.30 „	0·6 c.c.
180·5 c.c.	5 „	0·2 c.c.	177·5 c.c.	5 „	0·6 c.c.
180·3 c.c.	5.30 „	0·2 c.c.	177·0 c.c.	5.30 „	0·5 c.c.
	Next day.			Next day.	
169·5 c.c.	10 A.M.	0·315 c.c.	170·0 c.c.	10 A.M.	0·178 c.c.
168·6 c.c.	12 „	0·225 c.c.	169·3 c.c.	11.30 „	0·23 c.c.
				3rd day.	
			160·4 c.c.	9 A.M.	0·169 c.c.

III. *Buxus sempervirens* var. *arborescens*.—Specimens taken after similar exposure showed at first no assimilation, but after 3 hours at 15° C. weak and in 1 day fairly active from all parts with normal chlorophyll grains.

8 grammes green leaves. (Twigs=1·7 grms.)				8 grammes living but browned leaves. (Twigs=1·3 grms.)			
Reading.	Time.	CO_2 evolved per ½ hour.		Reading.	Time.	CO_2 evolved per ½ hour.	
180·0 c.c.	11 A.M.			181 c.c.	11 A.M.		
178·5 c.c.	11.30 "	1·5 c.c.	Darkness.	179·5 c.c.	11.30 "	1·5 c.c.	Darkness.
177·8 c.c.	12 "	0·7 c.c.		178·8 c.c.	12 "	0·7 c.c.	
176·0 c.c.	2.30 P.M.	0·33 c.c.		178 c.c.	2.30 P.M.	0·16 c.c.	
175·4 c.c.	3 "	0·6 c.c.		177·3 c.c.	3 "	0·6 c.c.	
174·6 c.c.	3.30 "	0·8 c.c.		176·7 c.c.	3.30 "	0·6 c.c.	
173·1 c.c.	4.30 "	0·75 c.c.	Light.	175·5 c.c.	4.30 "	0·6 c.c.	Light.
172·5 c.c.	5 "	0·6 c.c.	Darkness.	174·7 c.c.	5 "	0·8 c.c.	Darkness.
171·8 c.c.	5.30 "	0·7 c.c.		173·8 c.c.	5.30 "	0·9 c.c.	
	Next day.				Next day.		
158·5 c.c.	9.30 A.M.	0·83 c.c.		159·1 c.c.	9.30 A.M.	0·92 c.c.	
	3rd day.				3rd day.		
157·7 c.c.	10.30 A.M.	0·4 c.c.		158·2 c.c.	10.30 A.M.	0·45 c.c.	

In the case of *Buxus* it is possible that the large amount of CO_2 which the frozen leaves at first evolve when thawed is partly due to the setting free of pre-formed CO_2, retained mechanically by the frozen tissue. Hence the subsequent fall followed by a secondary rise to the true respiratory maximum.

Without attaching too much importance to the results thus obtained, still it appears that (1) respiration may be active whilst assimilation is still absent, and (2) respiration recovers from exposure to a low temperature more rapidly and responds more readily to an increase of temperature than assimilation does.

In certain cases preparations which at 1° C. show a weak evolution of oxygen, when brought to a temperature of from 15° C. to 20° C. cease in a few minutes to evolve oxygen, after a short interval, which may be as long as an hour, recommencing to evolve oxygen with normal rapidity. This stoppage does not appear to be due, as at first seems to be the case, to the effect of

TABLE J.

	6 hours at 0°·0 C. to 0°·2 C.	1 day at 0°·0 C. to 0°·2 C.	2 days at 0°·0 C. to 0°·3 C.	5 days at 0°·5 C. to 1–2° C.
Chara fragilis.	No evol^n of O. Slow rotation in most end cells. At 20° C. rotation soon rapid; evol^n of O commences in 3 h., and is fairly active in 5 h.	Apical and cortical cells dead. In 2 h. at 20° C. weak and in 4 h. fairly active evol^n of O from many medullary cells.	Same as after 1 day.	End and cortical cells dead. Most medullary cells living and show in 3 h. an active evol^n of O.
Elodea canadensis.	No evol^n of O. Few cells, slow creeping rotation. At 20° C. rotation at once increases, in 5 minutes is fairly active. Assim. is fairly active in 10–15 minutes.	Rotation as before but evol^n of O active after 3 h. at 20° C.	Leaves all living. Assim. as after 1 day. No rotation: slow in 15 minutes at 20° C., active in 3 h.	No rotation and no evol^n of O. In 15 minutes at 20° C. slow rotation. In 3 h. weak evol^n of O and active rotation. In 5 h. assim. is mod. active, and in 1 day quite active.
Nitella flexilis.	1 day at 0°·2 C. to 0°·5 C. rotation present but slow. No evol^n of O. In 15 min. at 20° C. rotation active, but no evol^n of O. Weak evol^n of O. in ½ h., quite active in 2 h.		4 days at 0°·5 C. to 1°·5 C. Nearly all cells living; large axial cells show slow rotation. In ¼ h. at 20° C. rotation active in axial cells, slow in rest; few cells show weak evol^n of O. In 1 h. rotation normal, evol^n of O fairly active, and quite active in 3 h.	
Cladophora species?	After 1 day at 0° C. to 1° C. No evol^n of O. Many cells dead, especially in younger branches. After ¼ h. at 20° C. weak evol^n of O from older living branches, stronger in 1 h. and fairly active in 3 h.			

the shock induced by the sudden change of temperature, causing a temporary stoppage of assimilation, for in normal actively assimilating preparations the evolution of oxygen is not perceptibly affected by sudden changes of temperature for short periods of time, provided that the range lies within the critical points. The phenomenon is probably simply due to respiration increasing more rapidly than and temporarily overpowering assimilation.

The main results obtained by experimenting with freshwater algæ, &c. are given below, and show that these plants are not very resistant to cold, all those examined being killed by being frozen.

TABLE K.

	3 days at 0°·5 C. to 2° C.	3 days averaging 2° C. (1° C. to 4° C.).
Œdogonium species?	Nearly all filaments living. No evol^{n} of O, weak in 1 h. at 20° C., fairly active in 3 h., about normal in 5 h.	No evol^{n} of O (at 1° C.); in ½ h. at 20° C. weak and in 3 h. active.
Spirogyra species?	Most filaments dead, few living, plasmolysable and with normal Chl. bands, but these do not recover and soon die.	Most filaments living. No evol^{n} of O (at 1° C.), in 1 h. at 20° C. weak, in 3 h. about normal assim., in all living cells.
Chara fragilis.	No assim. or rotation. Most end cells dead, nearly all cortical and medullary cells living. In 15 min. at 20° C. veay weak evol^{n} of O, but no rotation. Rotation commences in 1 h., and in 3 h. both it and assim. are active.	*Nitella flexilis.*—Slow rotation in older axial cells only. No evol^{n} of O (at 1° C.). Evol^{n} of O, shown first by the younger branches in which rotation is still slow. In 1 h. at 20° C. rotation and assim. active.

With freshwater plants even after exposure reaching nearly to the critical point, no very marked after-effect is produced upon assimilation. This is probably because, owing to their slight powers of resistance to cold, the temperatures to which they can be exposed without being permanently injured are necessarily relatively high. It is very difficult, if not impossible, to cause even by very prolonged exposure to cold a stoppage of rotation in the larger axial cells of *Nitella* without their being permanently injuriously affected, and probably the same is the case with the

internodal medullary cells of *Chara*. In other cases, it is comparatively easy by exposure to cold to cause a stoppage of rotation. There does not seem to be any inherent essential connection between the recovery of rotation and the recovery of assimilation—the one may be active whilst the other is still weak or absent.

Experiments with more resistant land plants show that within certain limits a short exposure to a very low temperature produces the same result as a longer exposure to a higher temperature.

TABLE L.

Plants for 3 weeks at average temperature of −2° C. to −3° C. Examined at 1° C. All remained living.	
Ceratodon purpureum; *Oxalis Acetosella.*	Weak evol^{n} of Oxygen, which after 1 h. at 15° C. is active.
Bryum cæspititium; *Sphagnum acutifolium.*	No evol^{n} of O; commences in ¼ h. at 15° C. and is in 1 h. active.
Selaginella helvetica; *Marchantia polymorpha*; *Lunularia rediviva.*	No evol^{n} of O; in 1 h. at 15° C. fairly active and in 3 h. quite active.

TABLE M.

Plants for 15 hours at a temperature falling from −2° C. to −9° C. Examined at 1° C.	
Brassica Napus.	Seedlings. Assim. faint or imperceptible; in 3 h. at 15° C. active.
Hedera Helix; *Cupressus sempervirens.*	No evol^{n} of Oxygen, but in 3 h. at 15° C. assim. is quite active.
Buxus sempervirens; *Thuja orientalis.*	No evol^{n} of Oxygen. In 3 h. weak and in 1 day fairly active assim. A few leaf-cells in *Buxus* die and do not recover.
The same 5 plants exposed for 6 h. to a temperature falling from 0° C. to −8° C. showed when examined at 1° C. a weak but distinct power of assimilation, which after 1-2 h. at 15° C. became active.	

A series of experiments performed with plants from the temperate, cold, and tropical houses showed as regards the function of assimilation very different powers of resistance to exist between these three classes of plants. In Table N the leafy branches of cool temperate plants were exposed under

TABLE N.

Plants from cool temperate house, average temperature 10° C.

	For 6 hours at −4° C. to −6° C.	14 hours at −2° C. to −8° C.	2nd day, temp. −6° C. to −10° C.	3rd day, temp. −5° C. to −8° C.
Ilex latifolia.	No evolⁿ of O. In 1 h. at 15° C. assim. is quite active.	Few cells killed and Chl. grains disorganized. No assim.; in 3 h. weak and in 1 day active.	Few leaf-cells living, plasmolysable, and with normal Chl. grains. No recovery, and in a few hours all cells are dead.	All leaf-cells dead.
Euonymus japonicus.	Distinct but weak assim., which after 1 h. at 15° C. is active.	As in *Ilex*, but assim. active in 3 h.	As in *Ilex*.	As in *Ilex*.
Rhamnus Alaternus.	As in *Euonymus*.	As in *Euonymus*.	Many cells dead. No assim.; in 5 h. at 15° C. weak and in 1 day fairly active assim. in all living cells.	Plenty of living leaf-cells. No assim.; feeble in 3–5 h., fairly active in 1 day.
Prunus Laurocerasus.	As in *Euonymus*.	As in *Euonymus*.	As in *Rhamnus*.	Many cells dead. After 5 h. at 15° C. still no assm., in 1 day distinct but weak assim. in all living cells.

TABLE O.

	1 day. Temp. 0°·2 C. to 1° C.	2 days. Temp. 0°·0 C. to 1°·0 C.	3rd day. Temp. 0°·5 C. to 1°·5 C.	5th day. Temp. 0° C. to 1° C.
Bambusa arundinacea; *Hibiscus Rosa-sinensis*; *Tradescantia geniculata.*	Distinct but weak assim., which in ¼ h. at 15° C. is active.	Weak evol^n of O, which in ½ h. at 15° C. is quite active.	Very weak evol^n of O, which is in 1 h. at 15° C. active.	No evol^n of O, none after 2 h. at 6–8° C., then at 15° C. in ¼ h. weak evol^n of O, which in 1–3 h. is active.
Buddleia diversifolia.	No evol^n of O, but at 15° C. assim. commences in a few minutes, and is active in ½ h.	No evol^n of O, but in 1 h. at 15° C. active assim.	....	No evol^n of O. After 2 h. at 6–8° C. weak, and at 15° C. is then in 1 h. active.
Alpinia officinarum.	As in *Buddleia.*	As in *Buddleia.*	....	No evol^n of O. After 2 h. at 6–8° C. still none, then at 15° C. in ½ h. faint, in 1 h. fairly, and in 3 h. quite active.
Ficus parietalis.	As in *Bambusa.*	Weak evol^n of O, which in ¼ h. at 15° C. is active.	No evol^n of O. At 15° C. in 1 hr. fairly, and in 2 h. quite active.	As in *Alpinia.*

TABLE P.

Tropical plants from hot-house, temperature 15° C. *to* 25° C., never below 10° C.

	At 1° C.	At 1° C. for 4 hours, and then at 20° C.	At 5° C.	At 10° C.
Epidendrum floribundum.	Evol^n of O ceases in $\frac{1}{4}$ to $\frac{1}{2}$ h. At 20° C. at once recommences and is in 10 to 15 minutes active again.	Evol^n of O recommences in $\frac{1}{4}$ h. and is active in $\frac{1}{2}$ h.	Evol^n of O ceases in an hour, at 20° C. at once recommencing.	After 5 h. evol^n of O still quite active.
Aspidium violascens.	In 1 h. evol^n of O very weak, in 4 h. none. At 20° C. is in $\frac{1}{4}$ h. active again.	Weak evol^n of O in $\frac{1}{4}$ h., in $\frac{1}{2}$ h. fairly active.	After 4 h. weak evol^n of O still present, which at 20° C. in $\frac{1}{4}$ h. is active.	Evol^n of O remains active.
* *Mimosa pudica.*	Evol^n of O ceases in $\frac{1}{2}$ h., at 20° C. at once recommencing.	Weak evol^n of O in $\frac{1}{2}$ h., in 1 h. fairly active.	Evol^n of O ceases in 1 h. At 8° C. in 4 h.	Evol^n of O persists, but is weaker than normal.
	After 1 day at 1° C.		After 1 week at an average of 1° C. (0° C. to 2° C.).	
Aspidium violascens.	No evol^n of O, in $\frac{1}{2}$ h. at 20° C. faint traces, in 1 h. moderately active, and in 2 h. quite active.		No evol^n of O, faint in 3 h. at 20° C., stronger in 5 h., fairly active in 1 day.	
Epidendrum floribundum.	No evol^n of O, in $\frac{1}{4}$ h. at 20° C. just perceptible, in $\frac{1}{2}$ h. weak, and in 1 h. active evol^n of O.		Many leaves with black dead patches. No evol^n of O, none after 5 h. at 20° C., weak in 12 h., fairly active in 1 day.	

* Since in *Mimosa* there is neither a temporary nor a permanent stoppage of assimilation as the result of section-cutting, it follows that there is no direct connection between Assimilation and Irritability, a maximal excitation of the latter exercising no influence upon the former. In the drooping position of the leaves the actual amount of assimilation of the plant as a whole is certainly much lessened, but only because the position thereby assumed is, for physical reasons, less advantageous for assimilation, the inherent power of assimilation remaining unaffected. Thus, leaflets of *Mimosa pudica* and *Oxalis Acetosella* are found, when examined at night in the nyctitropic position, to be capable, on sudden exposure to light, of as active assimilation as when in the expanded diurnal position.

metal covers during a period of severe frost, the range of temperature being taken by a differential thermometer, after exposure the plants being thawed and examined at 1° C.

Leafy branches taken from the warm house (average temperature 10° C. to 20° C.) were kept in a glass case surrounded by snow, examined at 1° C. and then brought to a temperature of 15° C. (Table O).

With tropical plants assimilation ceases to be perceptible at a temperature several degrees above zero (Table P).

Experiments were also made with three-weeks old seedlings of certain plants developed under precisely similar conditions with regard to temperature (30° C.), exposure to light, amount of moisture, &c.

TABLE Q.

	At −2° C. to −1° C. for 1 day, and then examined at 1° C.	3 days at −1° C. to 1° C., then 1 day at −3° C. to −5° C.
Vicia Faba; *Helianthus annuus.*	All leaves living. Very faint evol^n of O at 1° C. In 1 h. at 20° C. fairly, and in 2–3 h. quite active evol^n of Oxygen.	Almost all leaves and leaf-cells living. At 1° C. at first no evol^n of O, in ½ hr. at 20° C. moderately, and in 1–2 h. quite active evol^n of O.
Ricinus communis; *Lupinus albus.*	All leaves living. At first no evol^n of O. In 1 h. at 20° C. fairly, and in 2–3 h. quite active assim.	
		At −1° C. to +1° C. for 1 day.
Zea Mays; *Phaseolus vulgaris.*	Few leaves killed, rest show no evol^n of O, none after 2 h. at 20° C., weak in 3 h., fairly active in 5 h., normal in 1 day.	No evol^n of O at 1° C., but assim. returns rapidly at 20° C. and is normal in 1 hr. and all leaves remain living.

The above table clearly shows that the most important factor in determining the resistant power of any given plant to cold is the hereditary nature and disposition of the plant itself, but how this acts and what the exact relation between the two may be is impossible to say.

Though death caused by freezing is due to the withdrawal of water from the cell to form ice crystals, nevertheless resistance to desiccation and resistance to freezing are not necessarily

coincident. All plants which can withstand desiccation can also withstand freezing; but it is only plants which are very intolerant of, and very readily damaged by, a loss of water that are easily killed by freezing at a few degrees below zero. To very low temperatures, since the withdrawal of water is here complete, only those plants are resistant which are capable of withstanding complete desiccation *.

The latent period of return of assimilation after exposure to cold is nearly always of relatively short duration, and is possibly produced by the withdrawal of water from the protoplasm, and represents the time necessary for the assimilatory plasma to completely return to its normal condition of metabolic activity.

As regards the temperature at which assimilation commences, Cloez and Gratiolet † found that it began in *Potamogeton Ceratophyllum* and *Conferva* between 10° C. and 15° C., and in *Vallisneria* above 6° C. With larch-leaves Boussingault ‡ detected an evolution of oxygen at 0°·5 C. to 2°·5 C., and with meadow grasses at 1°·5 C. to 3°·5 C.; whilst Heinrich § found that with *Hottonia palustris* bubbles of oxygen were first given off at 2°·7 C. By the more delicate Bacterium method an evolution of oxygen can be detected at temperatures several degrees lower than the above. It appears that all evolution of oxygen ceases in tropical plants between 4° C. and 8° C., in warm temperate, subtropical, and water-plants between 0° C. and 2° C., whilst in cool temperate, arctic, and alpine plants assimilation only ceases when the plants are frozen, *i. e.* at a few degrees below 0° C. In this last case the stoppage of assimilation is of purely physical origin, and is due to the withdrawal of water from the protoplasm to form ice crystals, leaving the assimilatory plasma in what is virtually a more or less completely desiccated condition.

In many cases freezing and the stoppage of assimilation are coincident with a cessation of vitality, but in others the plants may be completely frozen and assimilation stopped without the power of recovery being lost. In such plants both respiration and assimilation may function at zero, or even, and especially the former, a few degrees below it. Thus Clausen finds that

* See Pfeffer, 'Physiologie,' Bd. ii. Cap. 10.

† Cloez and Gratiolet, in Journ. univ. Sc. France et à l'étranger, 30 Oct., 1850, No. 878.

‡ Boussingault, in Ann. Sc. nat. sér. v. t. x. (1869) p. 336.

§ Heinrich, in Landw. Versuchsst. xiii. 1871, p. 136.

cells of seedlings of Lupines only freeze at -4° C., and that hence above this temperature respiration can still continue. At zero he finds respiration to take place with $\frac{1}{10}$th to $\frac{1}{15}$th its optimal activity. Jumelle finds that with Conifers and Lichens respiration may not entirely cease till a temperature of -10° C. is reached. This statement is rendered more probable by the researches of Dixon and Joly *, who find that in a plant-tissue all the intracellular and imbibed water may not freeze until the temperature is lowered to -10° C. or -12° C. As regards assimilation, Jumelle states that *Evernia Prunastri*, *Picea excelsa*, and *Juniperus communis* at from -30° C. to -40° C., if exposed to light, evolve oxygen and absorb CO_2. He supposes that the heat-rays which fall upon the specimens along with the light-rays when exposed to light may prevent all the water of the plant-cells being frozen even when exposed to from -30° C. to -40° C., and thus permit of assimilation taking place, though in darkness all the contained water is frozen and respiration ceases at -10° C. To this hypothesis two objections may be made:—(1) the same heating-effect would be produced upon the registering thermometer as upon the exposed specimens; and (2) if such a special heating-effect were produced, then the experiments would be valueless, for the specimens would be exposed to a temperature higher than that registered by the thermometer.

It is possible that the changes in the composition of the air of the receiver observed by Jumelle at these low temperatures may be due not to the continuance of any actual assimilation, but to physical diffusion, carbonic acid being slowly absorbed and oxygen slowly exhaled from the frozen specimens. The following facts make probable this assumption, thus:—(1) The amounts of gas absorbed and exhaled are relatively small. (2) The volumes of oxygen and CO_2 which are exhaled and absorbed do not at all correspond. (3) The gaseous interchanges from the first diminish in amount as the exposure continues. (4) The gaseous interchanges do not alter in amount within very wide ranges of such low temperatures, and only increase when the temperature is raised to a few degrees below zero.

When the experiment is started, the plants being exposed to light, and at first at a temperature above zero, will continue to assimilate until the temperature falls below zero and the plants

* "The Path of the Transpiration-current," in Annals of Botany, 1895.

are completely frozen. The intracellular and extracellular gases which the frozen tissues of the specimens now hold will contain a much larger percentage of oxygen, and a much smaller percentage of CO_2, than the assimilatory mixture of air and CO_2 contained in the receiver in which the plant is lying. Owing to the frozen condition of the tissues, this inequality is only slowly adjusted by diffusion to and from the surrounding air contained in the receiver, the result being that the air of the receiver will lose CO_2 and gain oxygen just as if slight assimilation had taken place.

Besides the above, there are very weighty *à priori* reasons for doubting that any assimilation could possibly take place at a temperature of from $-30°$ C. to $-40°$ C. As we have seen throughout, assimilation seems to be a function which remains active through much narrower ranges of temperature than respiration does. Thus the minimal temperature for respiration is apparently, as a general rule, several degrees lower than that for assimilation, whilst the maximal temperature for respiration is from 5° C. to 15° C. above that for assimilation, and the same general differences appear to hold good for all plants, a difference in the minimal and maximal points for respiration being accompanied by a corresponding difference in those for assimilation.

Effect of Irrespirable Gases upon Assimilation.

Direct observations were first made under the microscope in a gas-chamber with a hanging drop and *Bacterium Termo*, mosses and water-plants being examined (*Bryum cæspititium*, *Orthotrichum affine*, *Dicranum scoparium*, *Elodea canadensis*, and *Chara fragilis*). In an atmosphere of H, the preparations continue to evolve oxygen for as long as they are exposed to light (10 to 12 hours), the necessary CO_2 for assimilation being supplied by the Bacteria in the hanging drop. At the end of this time the evolution of oxygen is with moss-leaves still quite active, but with *Chara* and *Elodea* has, as a general rule, become distinctly less active than it was at first.

If preparations of *Chara* or *Elodea* are kept in a stream of H, either in light or in darkness, they finally in from a few to many hours lose the power of assimilating and evolving oxygen, though they may still continue to show rotation. Even if kept exposed to light in a current of an assimilatory mixture

of H and CO_2, the preparations also finally lose the power of assimilation.

Moss-leaves, however, under these conditions retain the power of assimilation for an indefinite length of time. The explanation is that, in the first two plants under these abnormal conditions, a state of assimilatory inhibition is induced in the exposed specimens, from which at first recovery is possible if the plants are brought under normal conditions again, *i. e.* on exposure to air after a longer or shorter latent period the power of assimilation returns. If the exposure has been too prolonged, the power of recovery is lost and the preparations finally die.

If green plants are exposed to light in an atmosphere of H, at the end of several hours' exposure the surrounding gas is found to have undergone no perceptible change in composition, but nevertheless during the whole time of the exposure both assimilation and respiration are going on, and the specimens are continuously evolving traces of both oxygen and CO_2, which may be detected by the Bacterium method and by Phenolpthalein respectively.

In an atmosphere of pure CO_2 in all cases, assimilation and evolution of oxygen cease almost immediately (in 1 to 2 minutes). If the CO_2 is now replaced by H, a normal evolution of oxygen is at once shown, but if the preparations are kept in an atmosphere of CO_2 for some time they may only recommence to evolve oxygen and assimilate after a longer or shorter period of time has elapsed. In an atmosphere of CO_2 moss plants may remain living for many days or even weeks, but *Chara* or *Elodea* cease to show rotation after 15 to 20 minutes or 5 to 10 minutes respectively, and after 2 or 3 hours' immersion are killed; whereas in an atmosphere of pure hydrogen *Chara* may remain living for half a day (12 hours). In an atmosphere of hydrogen rotation gradually becomes less and less rapid, but when suddenly surrounded by CO_2 rotation undergoes an immediate diminution to as much as one half its previous velocity, the difference being due to the fact that in the latter case, besides the removal of the necessary oxygen, a direct and immediate poisonous and retarding influence is produced.

Mosses, however, as well as many plants of lower organization, are remarkably resistant not only to the asphyxiating effects of immersion in an atmosphere of hydrogen, but also to the

poisonous action of an atmosphere of CO_2. Specimens of the above three mosses were kept in moist atmospheres of hydrogen and CO_2 at a temperature of from 15° C. to 20° C. in the darkness for long periods of time, and then examined.

The mosses are kept moist in a suspended tray within a graduated bottle which is filled with water. Gas is driven in, driving out water through the exit-tube the shorter distal end of which dips under mercury and leaving the receiver filled with the gas in question. In the same way, a mixture of gas with air or oxgygen in any given proportion can be readily introduced and when necessary, by first siphoning or driving water backwards and then driving it out again, fresh gas can be introduced without an exposure of the plants to the air being necessitated.

TABLE R.

	1 week in darkness in atmosphere of H.	4 weeks in darkness in 75 p.c. CO_2 + 25 p.c. air.
Bryum cæspititium.	Nearly all leaves and leaf-cells living and normal. Assimilation in a few leaves weak, but in rest active.	Most leaves and leaf-cells living. In a few leaves assim. is very weak, but in rest is active.
Orthotrichum affine.	Many older leaves and leaf-cells dead. Living leaves assim. absent or in parts only. Apical young leaves assim. is mod. active. In 1 day in D. Ch. in air, assim. active in most cases and in 2 days in all.	As in *Bryum*.
Dicranum scoparium.	Only apical leaves living, wholly or partly. No assim. In 1 day weak assim. in few leaves, in 2 days weak in all leaves, active in some, and in 4 days active assim. in all living leaves.	Most leaves and leaf-cells living. Weak assim. in young leaves, in older leaves none. In 1 day assim. in all living cells, which in 2–3 days is normal and starved appearance of cells disappears.

For comparative purposes, plants were also kept for 4 weeks in darkness in moist air at 15° C. On examination, the leaves of these were found to be almost all living and showed fairly active or in a few cases only weak assimilation. The chlorophyll grains are, beyond having a slight yellowish tinge and being devoid of starch, normal, whilst the protoplasm is clear, vacuolated, and

transparent, and in *Dicranum* without oil-drops. After 2 or 3 days' exposure to light, the plants are quite normal in all respects. The slight yellowish tinge acquired by the chlorophyll grains and the starvation phenomena exhibited are therefore results of the absence of light.

Table S (p. 407) gives the results of keeping the mosses for long periods in darkness in an atmosphere of CO_2, temperature averaging 15° C.

It is worthy of remark that in many cases, after prolonged exposure, cells which show no assimilation do not recover that function even though they may remain living and plasmolysable for 2 or 3 days. Such cells have permanently lost the power of assimilation and are, as long as they live, nourished as a non-chlorophyllaceous cell is, though to all outward appearance the chlorophyll-apparatus is normal and intact. Attempts were made to keep such cells living by supplying them with artificial nutrient media, but without success. Apparently when asphyxiation produces a permanent stoppage of assimilation, it involves internal changes exercising so profound an influence upon the vitality of the cell that sooner or later death follows as a necessary consequence.

In *Dicranum* the sequence of changes from life to death are :—The protoplasm gradually becomes more opaque, granular, and greyish, and also less readily plasmolysable, assimilation becomes weaker and weaker and finally stops; in this condition the cell may remain with the chlorophyll grains green and unaltered for a few days; in the first stages assimilation can return and the cell become normal again, but in the later stages the power of recovery is totally lost, and this is finally followed by the shrinking of the protoplasm from the cell-wall, the chlorophyll grains turning first yellowish and then rapidly losing all colour, until finally the cell-cavity is incompletely occupied by a greyish, rather opaque, but more refractive than when living, granular amorphous mass in which neither colour nor chlorophyll grains can be distinguished.

Boussingault * first noticed the phenomena of "asphyxie" and found by means of the gas-analytical method that with Phanerogams in H, CH_4, N, or CO_2 asphyxiation takes place and

* Boussingault, 'Agronomie, Chimie Agricole et Physiologie,' 1868, iv. p. 329.

TABLE S.

	In CO_2 for 1 week at 15° C.	In CO_2 for 2 weeks.	In CO_2 for 4 weeks.
Bryum cæspititium.	Many leaves dead, but rest all or many cells living and showing active assimilation.	Most leaves and leaf-cells living. Assimilation fairly active, but in many cases weak and in few leaves imperceptible. In 1 day normal assimilation in all living leaves.	Apical tufts mostly living. No evolution of oxygen. In 4 hours weak assimilation in many cells, in most still none. In 1 day many cells die, but rest show weak or moderately active assimilation, and in 2 days active in all cases.
Orthotrichum affine.	Younger leaves living, but assimilation weak or imperceptible. In 2 hours assimilation stronger and in 1 day normal.	Younger leaves living, a few show weak assimilation, mostly none. In 3–4 hours weak assimilation in most leaves, in 1 day fairly active.	Younger leaves, more or less cells living, but no assimilation. In 4 hours most living cells show weak assimilation, which in 1 day is fairly active.
Dicranum scoparium.	Most leaves living. Assimilation weak to moderately active, and in 1 to 2 hours about normal.	Upper leaves mostly living. Assimilation absent, but in inner leaves of apical tuft assimilation weak to active, and in 3–4 hours normal. In rest normal assimilation in 1 to 2 days.	Younger leaves, more or less cells living. No assimilation, in 1 day assimilation still weak or absent. In 3–4 days few apical tufts still living and these show active assimilation.

assimilation is first weakened and then permanently stopped. Even with mosses which are very resistant to asphyxiation similar results are finally produced, and, as we have seen above, the stoppage of assimilation is not necessarily permanent, but instead recovery may take place if the plants are brought under normal conditions again.

Effects of Ether upon Assimilation.

F. Schwarz *, working with the bubble-counting method, found that in a saturated watery solution of ether water-plants cease in a few minutes to assimilate and no recovery takes place, the specimens having been fatally affected. Similarly, Pringsheim †, using the Bacterium method, found that anæsthetics such as chloroform and ether stop assimilation, but the cells cannot be restored to life and the chlorophyll apparatus is changed and altered. Bonnier and Mangin ‡, using the gas-analytical method, found that with certain Phanerogams, by using a measured quantity of ether, assimilation may be stopped whilst respiration continues unchecked, thus confirming the results obtained by Claude Bernard with chloroformed water-plants ('Leçons sur les phénomènes de la vie,' 1878, p. 278).

In the following experiments with Mosses, the plants were kept in an atmosphere containing ether vapour for varying periods of time. After being kept for 30 minutes and for 1 hour under a bell-jar over a saturated solution of ether in water (10 parts of water to 1 part ether) and then examined in the usual method, the three mosses experimented with gave the results shown in Table T. Care must be taken that no appreciable amount of ether remains adhering to the leaves, as a very slight amount of ether is sufficient to inhibit the movement of *B. Termo*. A few seconds' exposure to air is, however, sufficient to allow of the evaporation of all the ether from the leaves examined.

* F. Schwarz, "Zur Kritik der Methode des Gasblasenzählens an submersen Wasserpflanzen," in Bot. Untersuch. v. Tübingen, 1881, p. 102.

† Pringsheim, "Ueber die Abhängigkeit der Assimilation grüner Zellen von ihrer Sauerstoffathmung," in Sitzungsberichte der Akademie der Wissenschaften zu Berlin, 1887.

‡ Bonnier and Mangin, in Ann. Sc. nat. sér. vii. t. iii. 1886, p. 14.

TABLE T.

	After 30 minutes' exposure.	After 1 hour's exposure.
Bryum cæspititium.	Few leaves, and leaf-cells dead, but rest living and assimilating actively.	Most leaves and leaf-cells living, and in all of these assimilation is active.
Orthotrichum affine.	Most leaves and leaf-cells living and assimilation active, but a few leaves with plenty of living leaf-cells show no perceptible or extremely weak assimilation. In 2-3 h. many of these cells die, but the rest show normal assimilation.	Many leaves and leaf-cells dead and in living cells assimilation faint or imperceptible. In 5 h. rather weak, and in 1 day active assimilation in all living leaves.
Dicranum scoparium.	As in *Orthotrichum.*	Most leaves and leaf-cells living and assimilation fairly active. Few leaves with all or many cells living, no assimilation. Many of these die in from a few hours to a day, but in rest assimilation returns and is normal in from 5 h. to 1 day.

Using strong solutions of ether and short exposures the stoppage of assimilation seems, especially with *Bryum*, to be almost immediately followed by the death of the cell, and hence in such cases it is difficult to find living but non-assimilating cells. A series of more prolonged exposures were therefore made, the same plants being placed under bell-jars over a given quantity of a $\frac{1}{10}$ saturated watery solution of ether (1 part ether to 100 H_2O), the resulting atmosphere containing 1 volume of ether to from 15 to 30 of air, and hence sufficient to burn or form an explosive mixture. During prolonged exposures the atmosphere is renewed from time to time and fresh ether solution introduced.

Table U shows clearly the pronounced resistant power exhibited by Mosses to prolonged exposure to dilute ether-vapour, as well as the marked stoppage of assimilation which finally occurs. In *Dicranum* one result of prolonged exposure is that the protoplasm in many cases becomes darker, more greyish and opaque than normal; but this peculiarity is exhibited by cells in which assimilation is still present, and may remain for some time in cells to which the power of assimilation has returned.

TABLE U.

	After 18 hours' exposure.	After 3 days.	After 6 days.
Dicranum scoparium.	Most leaves and leaf-cells living. Weak assim. in leaves of apical tuft, older leaves none, but in 2–3 h. weak assim. After 1 day in D. Ch. few living leaves, still no assim, but in 2 days normal assim. in all living leaves.	Apical leaves living but assim. weak; older leaves, though plenty of leaf-cells living no assim. In 1 day most living leaves assim. fairly active, few still not assimilating are by 2nd day dead; rest assim. normally.	Upper leaves more or less leaf-cells living but no assim. In from 2–3 h. weak assim. in most living leaves, which after 1 day is active in the upper leaves, and in 2–3 days all living leaves show about normal. assim.
Bryum cæspititium.	Almost all leaves and leaf-cells living and assim. active.	Most leaves and leaf-cells living. In most apical leaves assim. fairly active, but in rest assim. weak or absent. In 1 day normal assim. in all living leaves.	Many plants with more or less leaves and leaf-cells living. Few young leaves show weak assim., rest none. In 1 day assim. fairly active, but few living leaves still assim. In 2–3 days all living leaves show normal assim.
Orthotrichum affine.	Almost all leaves and leaf-cells living, but assim. in most cases weak, but in 2–3 h. is normal.	Almost all leaves living and showing weak assim., but in few cases none. In 1 day normal assim. in young leaves, and in 2 days in all cases.	Younger leaves weak assim., older leaves none. In 2–3 h. assim. in younger leaves active. In 1 day weak assim. in older living leaves, and in 2–3 days normal assim. in all cases.

It is not therefore concomitant with any loss of assimilatory power. In many cases the leaf-cells of *Dicranum*, especially at the bases of the leaves, exhibit a marked longitudinal striation, somewhat resembling that shown by a voluntary-muscle fibre. As before, the presence of this striation is quite independent of the presence or absence of assimilation, and disappears in a day or two if the cells remain living. In all cases the chlorophyll grains remain normal and unaltered whether assimilation be present or absent so long as the cell remains living.

Effects of Treatment with Acid upon Assimilation.

The acid employed was phosphoric acid, a 1-per-cent. solution being made by adding to 1 c.c. of a thick sirupy solution of H_3PO_4, 99 c.c. of water. A very dilute acid solution suffices to inhibit the movement of *B. Termo*. Thus in a 0·001 per cent. solution the movement continues apparently unaffected, in a 0·005 per cent. solution it remains but is not so active, in a 0·01 per cent. solution it slows and stops in a few minutes.

If preparations of end cells of *Chara* be made in a few drops of 0·01 per cent. H_3PO_4 in closed cells with Bacteria, rotation is soon slowed and in half an hour has in most cells ceased, though in others it is fairly active. As rotation ceases it undergoes temporary increases, attaining almost normal rapidity for a few minutes or so and then slowing again. These increases become shorter and less frequent, and finally the rotation comes to a standstill. In half an hour the Bacteria, which were at first motionless, begin to move, at first slowly whenever oxygen is present, and later more rapidly as the acid is absorbed by the *Chara* filaments. The cells in which rotation is still present show a weak but distinct evolution of oxygen. In about 2 hours rotation has stopped in all cases, but the evolution of oxygen does not cease for another 30 to 60 minutes; and now the power of recovery is completely lost, *i. e.*, with short exposure to, for *Chara*, relatively strongly acid solutions rotation ceases before the evolution of oxygen does, and when the power of assimilation ceases to be manifested, recovery is no longer possible.

Plants of *Chara* are fatally affected by immersion for several hours in a 0·001 per cent. solution of H_3PO_4, provided that a sufficiently large quantity of the acid solution is employed and that the specimens are quite free from chalk. *Chara* is excessively sensitive to immersion in acid media, and far more so

than other water-plants are. The chalky incrustation on *Chara* is certainly most important as a protection against the injurious action of even minute traces of fixed acid.

In plants of *Chara fragilis* after 16 hours' immersion in 0·0005 per cent. H_3PO_4 all end cells and most cortical cells are dead, no evolution of oxygen is shown, and none after 2 hours in water. In 4 hours a weak evolution of oxygen in parts and in some cells rotation can be seen. Next day all living parts show moderately active assimilation. In a few cases the cortical cells are killed and become white, blanched, and transparent, whilst the medullary cell, now rendered plainly visible, shows active rotation and assimilation.

The following tables give the results of experiments with water-plants and mosses, the plants being completely immersed in solutions of varying strengths for many hours and then examined after washing to remove all traces of adhering acid.

TABLE V.

	Elodea canadensis.	*Utricularia vulgaris.*
After 24 hours in 0·01 p. c. H_3PO_4.	At first no rotation, but in a few minutes it commences and is in ¼–½ hour active. Most leaves no assim., but weak evol^n of O in many, and in ½ h. weak evol^n of O in nearly all cases, in 1 h. in all cases and active in some. In 2–3 h. assim. is about normal.	Most branches weak evol^n of O, active in few, and in few none. In ½ h. weak evol^n of O in all cases, in many branches active, and in 1 to 2 h. about normal assim. in all cases.
After 24 hours in 0·02 p. c. H_3PO_4.	Central leaves of apical tufts and basal cells of most leaves living, but no evol^n of O. After 4 h. weak in many cases, after 8 h. in all cases, and in 1 day active evol^n of O from all living cells.	Younger branches living, but no evol^n of O. In 2 h. weak evol^n of O in some branches and in 4 h. in most. In 8 h. assim. is moderately active, but in few branches still weak or absent. In 1 day active assim. in all cases.
After 24 hours in 0·04 p. c. H_3PO_4.	Leaves of apical tuft more or less cells living, but no evol^n of O, none after 2 h., weak in few cases in 4 h.; in 8 h. weak assim. in most living cells, which in 1 day is moderately active.	Young adult branches partially or entirely living. No evol^n of O and none after 2 h. Weak in 4h. from most living branches, in 8 h. in few cases mod. active, but in some still none. In 1 day all living branches show from weak to mod. active assim.

TABLE W.

	1 day in 0·1 p. c. H_3PO_4.	After 2 days in 0·1 p. c. H_3PO_4.
Bryum cæspititium.	Plants almost unaffected.	In most leaves no evol^n of O from apical half, and here more or less cells may be dead. In rest active assim. In 1 day fairly active assim. in all cases.
Catharinea undulata.	As in *Bryum*.	Few leaves active, evol^n of O most weak, and all cells living; in many assim. absent, and here more or less cells dead. After 1 day weak evol^n of O in latter case, active in former.
Dicranum scoparium.	Nearly all leaves living. No assim. In 1 day weak or absent, but in 2 days active.	Most leaves and leaf-cells living. No assim. After 1 day assim. still weak or imperceptible. In 2–3 days several leaves die but in rest assim. is active.

It will be noticed that the mosses are very much more resistant than water-plants are; and though this is undoubtedly partly due to an inherent difference of vitality it is also certainly partly due to the fact that the acid solution penetrates with greater difficulty through the cell-walls of mosses than through those of water-plants. Pfeffer * has shown that the acid penetrates both cell-wall and protoplasm and appears in the cell-sap. The death of a cell immersed in an acid solution is soon followed by the contraction of the cell-contents and a rapid disorganization and decolorization of the chlorophyll grains.

Effect of Alkali upon Assimilation.

Darwin†, in 1882, noticed that treatment with dilute alkalies caused in many cases in the living cell a precipitate to be formed in the cell-sap, and that only after prolonged exposure in very dilute solution the cells are killed. The precipitate consists, as has been conclusively shown by Pfeffer ‡ and Klein §,

* Pfeffer, "Ueber Aufnahme von Anilinfarben in lebenden Zellen," in Untersuch. aus dem Bot. Inst. zu Tübingen, p. 290.

† Darwin, Insectivorous Plants, 1882.

‡ Pfeffer, *loc. cit.* (Ueber Aufnahme von Anilinfarben), p. 240.

§ Klein, in Flora, 1892, p. 400; in Ber. d. Bot. Gesell. 1892, p. 237; in Bot. Centralblatt, 1894, Bd. lvii. p. 187.

of tannin and other substances which the penetrating ammonium carbonate causes to be excreted. The phenomenon is therefore a proof that the alkali penetrates both the cell-wall and the lining protoplasm.

For experiments upon assimilation a 0·1-per-cent. solution of ammonium carbonate (0·1 gramme of salt to 100 grammes H_2O) was employed. In this strength of solution the movement of *B. Termo* remains active as long as oxygen is present, and hence the specimens can be examined after immersion in a 0·1-per-cent. without being washed or can be examined directly in it. To see whether recovery is possible or not it is of course necessary to remove all alkali by washing in either fresh water or water containing a trace (0·001 per cent. H_3PO_4) of acid.

Chara fragilis is killed by 16 hours' immersion in a 0·1-per-cent. solution, but after 10 hours' immersion, though most end and cortical cells are dead, a few are living and normal in appearance, but show neither rotation nor assimilation. After washing, in a few cells after 1 hour, a faint evolution of oxygen may commence, and in some cases this is shown at the end or middle of a cell only, over the rest of the cell no evolution of oxygen being shown, but after an hour or so spreading over the whole of the cell. In 2 hours a weak evolution of oxygen is shown from all the living cells, but still no rotation. In 3 hours slow rotation is shown, and after 6 hours all the cells which now remain living show moderately active rotation and assimilation.

The results obtained with *Elodea* and *Utricularia* are given in Table X. It will be noticed that apparently a two days' immersion produces a less marked effect upon assimilation than that produced during the first 16 hours. The reason is that the plants gradually withdraw more and more of the alkali from the solution, which at the same time loses ammonia by evaporation, so that although more than a litre was used in each case, at the end of two days only the very faintest trace of alkalinity was present. In this weakened solution a partial recovery may, if the action has not proceeded too far, take place.

In another experiment the plants were kept for two days in a 0·1-per-cent. solution several times renewed. *Elodea* was entirely killed; in *Utricularia* a few branches remained living and showed no assimilation, after 5 hours in water in a few cases weak but mostly still none, and after 1 day all living branches showed distinct assimilation, in most cases fairly active.

TABLE X.

	Utricularia vulgaris.	*Elodea canadensis.*
In 0·1 p. c. solution for 16 hours.	Almost all branches living. No evol^n of O. In 1 h. mod. active in parts, weak or absent in rest. In 4–6 h. all living branches show distinct evol$_n$ of O.	Most leaves living but no evol^n of O or rotation. In most leaves apical ⅓, though at first living and plasmolysable, dies without recovering. In 1 h. mod. active evol^n of O at bases of leaves, weak or none in middle portion. In 4 h. distinct assim. is shown by all living cells.
In 0·1 p. c. solution for 2 days.	Plenty of branches entirely or partly living. Most living young branches show weak evol^n of O, but rest show none. After 5 h. all living branches show weak evol^n of O, which in some younger branches is active. After 1 day fairly active assim. in all living branches.	In centre of apical tufts leaves with all cells living, and show weak evol^n of O, which in 2–3 h. is active. Rest of leaves only basal portions living, no evol^n of O, none after 2 h., weak in 5 h., and in 1 day all living cells show fairly active assim.

Living plants immersed in dilute acid or alkaline solutions tend in both cases to neutralize them, in the one case removing acid and in the other alkali. When a cell is killed by immersion in a solution of ammonia or ammonium carbonate, it does not contract but is fixed in a condition of rigor, whilst the chlorophyll grains, beyond becoming a somewhat darker green, do not alter, and retain their green colour, provided the solution remains alkaline, for several days without fading. Hence the appearance of the dead cells differs but little from that of a living one, and the loss of plasmolysability is the only reliable indication of death. As we have seen, a cell may remain plasmolysable for a short time after it has totally lost all power of recovery, *i. e.*, a dying cell does not immediately lose its plasmolysability; the complete change from life to death is by no means instantaneous, but involves a series of changes following one another in a certain sequence.

Effect of Antipyrin upon Assimilation.

Hauptfleisch * noticed that in *Elodea* immersion in a 1-per-cent. to 1·5-per-cent. solution of antipyrin causes pre-existant rotation to stop, hence it was to be expected that antipyrin might also have some effect upon assimilation. In a 3 per cent. solution of antipyrin *B. Termo* at once ceases to move, in a 2-per-cent. solution a few Bacteria show slow translatory movement, but in a few minutes all come to rest, whether oxygen is present or not; in 1-per-cent. fewer Bacteria move and not so rapidly as normally; in 0·5-per-cent. the movement is only slightly slowed, in 0·25-per-cent. is hardly at all affected, and in 0·1-per-cent. is as active as in water. Hence observations cannot be made in a strength of solution stronger than 1 per cent.; the recovery is followed after washing and keeping in fresh water.

The results of the experiments made with *Chara fragilis* and *Elodea canadensis* are given in Table Y.

As regards rotation, it must be remembered that in *Chara* the rotation is primary, arising from an internal stimulus which is in continual action, whereas in *Elodea* the rotation is secondary and is only called into action by external stimuli. Leaves of *Elodea*, with the cells in active rotation, if immersed in a 1-per-cent. solution of antipyrin, show in them very slow rotation, and in 2–3 hours none; in 2-per-cent. solution in half an hour a few cells still show slow creeping rotation, and in 1 hour rotation has entirely stopped, but on washing in water it very soon re-commences and is active again in a few minutes.

After even 4 hours' immersion in 1-per-cent. or 2-per-cent. antipyrin solution, the chlorophyll grains in *Chara* acquire a distinct brownish-green coloration, and may often, by becoming arranged in lighter (larger interspaces) and darker (smaller interspaces) areas, form an almost regular pattern over the cell. All these cells after 4 hours' immersion remain living and recover, the brownish tinge being still present after 1 day in water, when assimilation is quite active in all cases but disappears in 2–3 days. In *Elodea* all the cells remain living, but neither of these effects are produced. After 8 hours in either 1-per-cent. or 2-per-cent., a few cells in both *Elodea* and *Chara* are killed and do not recover. After 24 hours immersion, in *Elodea* only a

* P. Hauptfleisch, "Untersuchungen über die Strömung des Protoplasmas in behäuteten Zellen," in Pringsh. Jahrb. 1892, Bd. xxiv. p. 221.

TABLE V.

	Chara fragilis.	*Elodea canadensis.*
After 4 hours in 1 p.c.	Rotation present, but slower than normal. Mod. active evol^n of O. In water in $\frac{1}{4}$ to $\frac{1}{2}$ h. rotation and evol^n of O are active.	No rotation. Very weak evol^n of O, none in parts. In $\frac{1}{4}$ h. in water slow rotation, and in $\frac{1}{2}$ fairly active. Assim. still weak, but in 1 h. both are active.
4 hours in 2 p.c.	Slow creeping rotation. Evol^n of O extremely weak, or none. In $\frac{1}{2}$ h. evol^n of O mod. active, rotation quite active. In 1 h. active assim.	No assim. or rotation. In $\frac{1}{2}$ h. slow rotation, but no evol^n of O. In 1 h. rotation active, and evol^n of O. mod. active, and in 2 h. quite active.
8 hours in 1 p.c.	No evol^n of O, slow creeping rotation. In water in $\frac{1}{2}$ h. weak evol^n of O and mod. active rotation. Both active in 1 to 2 h.	No rotation or evol^n of O. Rotation active in many cells in $\frac{1}{4}$ h., and faint evol^n of O, which in $\frac{1}{2}$ h. is weak and in 1 h. active.
8 hours in 2 p.c.	No rotation or assim. In $\frac{1}{2}$ h. in water very weak or no evol^n of O and slow rotation. In 1 h. weak evol^n of O in all cases, and mod. active rotation. In 2–3 both active in all living cells.	No rotation or evol^n of O. Rotation active in many cells in $\frac{1}{4}$ h., but still no evol^n of O. In $\frac{1}{2}$ h. faint evol^n of O, which in 1 h. is moderately, and in 2 h. quite active.
24 hours in 1 p.c.	End and cortical cells dead, but over greater part of filaments medullary cells remain living and show in 1 h. weak and in 2 h. fairly active evol^n of O.	Almost all leaf-cells living. In $\frac{1}{4}$ h., active rotation in many cells but no evol^n of O. In $\frac{1}{2}$ h. very weak evol^n of O in many cases, and in 1 h. weak in all cases, in 2–3 h. active.
24 hours in 2 p.c.	Plenty of medullary cells living and showing in 1 h. faint, in 2 h. weak, and in 3–4 h. active evol^n of O.	Few leaf-cells at base and midrib living and showing in $\frac{1}{4}$ h. active rotation. After 1 h. no evol^n of O, weak in 2 h., and in 4 h. mod. active in parts. In 1 day all living cells show distinct assim.

few cells remain living, and in *Chara* only the medullary cells. After the latter have been kept for 2 or 3 days in water exposed to light the cortical cells bleach and become transparent, when the green rotating and assimilating medullary cells come distinctly into view and may remain living and assimilating for more than a week after the rest of the plant has been killed.

In the preceding paragraphs we have seen that the function of assimilation may be temporarily or permanently inhibited in a variety of ways—by cold, by heat, by desiccation, by asphyxiation, by etherization, and by treatment with acids, alkalies, or antipyrin. Boussingault was the first to notice that asphyxiation causes a stoppage of assimilation, but erred in supposing that the stoppage was always permanent and necessarily involved a loss of vitality. Boussingault's "asphyxie" is really only the last stage of asphyxiation.

Pringsheim has shown by experiments with *Chara* that it is possible to produce a condition of partial asphyxiation or inanition during which both assimilation and rotation cease. He concludes that inanition is produced by the absence of oxygen and that recovery can only take place if a supply of oxygen is introduced before inanition has passed into asphyxia, but does not take place if the specimen is exposed to light in an atmosphere of hydrogen containing a trace of CO_2. Working from this latter assumption, Pringsheim comes to the conclusion that assimilation is a purely protoplasmic function, being hence intimately bound up with rotation, ceasing when it ceases and recommencing when it recommences, and that the oxygen derived from the assimilation of CO_2 exists in the cell in the form of an oxygen-producing substance which undergoes decomposition and gives off oxygen on the outer surface of the cell only, no free oxygen being present in the interior of the cell*.

In support of his assumption that an oxygen-producing substance is present in every assimilating cell, Pringsheim evidences the fact that dead green and non-green cells commonly at death show an evolution of oxygen which can be detected by the Bacterium method. This statement evidently required further proof, as the movement of *B. Termo* might be affected by the nutritious substances which exude from the dying and contracting cell-contents. As a matter of fact, it was found that the nutritious substances evolved from a dying cell by exosmosis do aid the movement of the Bacteria and enable them to continue moving in a closed cell longer than they would have done in water alone, but that a distinct evolution of oxygen may take place from a dying cell previously actively assimilating.

In a closed cell in water *B. Termo* ceases to move in 2 or

* That free oxygen is actually present in the interior of the cell has now been definitely proved. See Pfeffer, "Oxydations Vorgänge in lebenden Zellen," in Abh. Sachs. Ges. Wiss. Leipzig (1889), pp. 375–516.

3 minutes; in neutral meat-extract or in a boiled watery extract of moss-leaves it takes 15 to 20 minutes longer to come to rest; whilst in the neighbourhood of dying cells which have been suddenly fatally injured the movement may continue, provided the cell was previously actively assimilating, for as long as 2 hours, and is independent of light. Cells killed by asphyxiation and non-chlorophyllaceous cells show no evolution of oxygen on death. The possibility of a slight evolution of oxygen taking place in many cases coincidently with death does not necessarily involve the assumption of the presence of a special oxygen-producing substance in the living assimilating cell. The slight amount of oxygen set free may have been held in a state of loose combination by the protoplasm, or the phenomenon may be a purely physical one, the actively assimilating cell when suddenly killed continuing for some time to slowly diffuse out the oxygen with which its substance was previously saturated.

Pringsheim's statement that recovery from inanition will not take place if the plants are exposed to light in an assimilatory mixture of hydrogen and CO_2, but only when free oxygen is admitted, is not true in the case of Mosses. The phenomena he observed in support of this contention, with *Chara*, can readily be explained when we remember that the inhibition of assimilation caused when inanition is produced will necessarily be followed by a longer or shorter latent period, and if we suppose that the addition of free external oxygen exercises a stimulating influence and shortens the latent period of recovery. The conditions as regards the absorption and evolution of oxygen are very different in an atmosphere of hydrogen containing a trace of CO_2 (such as Pringsheim experimented with) to what they are in ordinary air. In such an atmosphere, the oxygen's partial presence being *nil*, the cell will rapidly evolve all dissolved oxygen it may contain, an abnormal condition being thereby produced. This is shown by the fact that in preparations of *Chara*, even though exposed to continuous illumination, in a current of Hydrogen + a trace of CO_2, which continually removes from them all oxygen as fast as it is formed, inanition is finally produced and assimilation and rotation cease. Moss-leaves, however, under such conditions retain the power of assimilation for an indefinite length of time.

Engelmann * explains the phenomena on which Pringsheim's

* "Die Purpurbakterien und ihre Beziehungen zum Licht," in Bot. Zeit., Oct. 1888, p. 717.

reasoning is based, by supposing that the chlorophyll grains, normally accustomed to an abundant oxygen supply, are readily affected and soon killed by the deficient supply of oxygen, whilst the protoplasm, being more resistant, remains living and streaming. This, though partly true, is only a partial explanation. The condition first produced in the chlorophyll grain is one of inanition, characterized by an inability to assimilate, but from which recovery is possible. If the exposure goes too far, the chlorophyll grains are killed and lose their power of recovery, and this is quickly followed by the death of the entire cell.

That even in *Chara* a supply of external oxygen is not always necessary for the recovery from inanition is shown by the fact that end cells of *Chara* which had temporarily lost the power of assimilation, if kept in carefully closed cells under water exposed to light, recovered and recommenced to assimilate.

If preparations of *Chara* are kept in closed cells thinly ringed with vaseline in the darkness, in many cases the end cells remain living and show distinct though slow rotation for many days, and in certain cases for as long as five weeks, though exposed to light for less than one minute each week. No loss of water takes place from such a cell; *Bacterium Termo*, if enclosed, comes to rest in a few minutes, and as the ringing remains intact it is difficult at first to explain the phenomena observed, for here apparently the rotation of *Chara* continues in the absence of oxygen for as long as several weeks, which is in direct contradiction to the results obtained in an atmosphere of hydrogen. It does not follow that because *Chara* in an atmosphere of hydrogen ceases to show rotation and finally dies, that therefore this effect is produced by the absence of oxygen, for it might readily be due to a direct action of the hydrogen itself. If, however, the preparations are carefully and thickly ringed with a mixture of vaseline and wax, or vaseline and paraffin, or if a considerable quantity of living *Bacterium Termo* is enclosed, in two or three days the end cells cease to show rotation and die. *Spirilla* and *Monas Termo*, for the movement of which the presence of the minutest trace of oxygen suffices, continue to move in thinly ringed preparations as above for an indefinite length of time, whereas in thickly ringed cells they cease to move in a few hours. Through the vaseline in the thinly ringed preparations, therefore, a trace of oxygen diffuses, and this is

sufficient to cause the movement of *Spirillum* and the rotation of *Chara* to continue, but is insufficient for the movement of *Bacterium Termo.*

Preparations of *Chara*, thickly ringed with a mixture of wax and vaseline and kept immersed in cold boiled oxygenless water in closed bottles in the darkness, gave the following results:—

After 20 hours.	All end cells living. In half no rotation, in rest slow creeping rotation. After a few minutes exposure to light, rotation quickens in those cells where it was previously present, and a weak evolution of oxygen is shown. In some cases a weak but distinct evolution of oxygen is shown before rotation commences. After 15 to 30 minutes' exposure to light, both rotation and assimilation are fairly active.
After 30 hours.	Most end cells are still living, but no rotation or assimilation is shown. Rotation soon returns on exposure to light, but assimilation mostly not for an hour or two. In some cases no recovery at all takes place. In a few cases slow rotation is shown after exposure to light, but assimilation does not recover and, later, rotation ceases and the cells die.
After 40 hours.	All cells are fatally affected and have lost the power of recovery.

In an atmosphere of hydrogen in the darkness all rotation ceases in *Chara* in about 8 or 10 hours, and in a current of hydrogen exposed to light is in from 10 to 14 hours extremely slow or absent. In a current of hydrogen, oxygen is continually being forcibly withdrawn from the filaments, as is shown by the fact that, when suddenly surrounded by an atmosphere of hydrogen, the filaments give off oxygen more rapidly than before, causing an increased activity of the movement of the surrounding Bacteria, and continue to do so for some time, especially if exposed to light. In the closed cell surrounded by oxygenless water, on the other hand, rotation stops, solely because all supply of oxygen from without is cut off, and ceases only when all stored intramolecular oxygen has been used up and the protoplasm has been reduced to its lowest possible condition of deoxidization.

If preparations of end cells of *Chara* are exposed to light in a hanging drop with *B. Termo* in a gas-chamber filled with pure CO_2, in about 10 minutes all evolution of oxygen * ceases, but

* *B. Termo*, in a hanging drop over an atmosphere of CO_2 containing a trace of oxygen, continue to move fairly actively, though after prolonged exposure the movement is weakened and finally stops.

very slow rotation still persists. In 20–30 minutes rotation also ceases. If now a rapid current of hydrogen is passed through till only mere traces of CO_2 are left, in 5 minutes a distinct evolution of oxygen is shown and slow rotation has commenced. In 15 minutes the evolution of oxygen is quite active, and in half an hour rotation is also quite active. In such experiments no external supply of oxygen reaches the filaments, and if Pringsheim's contention that free oxygen is never present in the interior of a cell were true, then this would be a case in which a recovery of both assimilation and rotation takes place without any oxygen being supplied from without, the oxygen necessary for the performance of rotation as well as of the other protoplasmic functions being supplied from the first by the assimilation of the cell itself. The experiment is, however, faulty, because the stoppage of the protoplasmic activity is due to a direct poisonous influence of the CO_2, and certainly takes place before the amount of free or loosely held oxygen present in the cell is reduced to its lowest ebb. It is quite possible that, if this latter condition were actually produced, no return or re-commencement of rotation or assimilation (taking for granted that in some of its stages at least assimilation is a plasmatic function) could occur without being started by a supply of oxygen from without. Such a condition, in which all free or loosely combined oxygen in the cell is removed down to the last molecule, seems to be rather a theoretical than a practical one, being impossible to produce without at the same time destroying the protoplasmic vitality.

There can be little doubt that assimilation is largely if not mainly a protoplasmic function, and that the chlorophyll pigment is simply a cooperative member in the assimilatory apparatus of the living chlorophyll body. Whether the function is located entirely in the plasmatic stroma of the chlorophyll grains, or also partly in the protoplasm immediately surrounding these, or in the general protoplasm of the cell, is immaterial to the question at issue, though all the evidence goes to show that assimilation in the special sense is restricted entirely to the chlorophyll grain. Of all the different modes of inhibiting assimilation described in the previous pages, two only are accompanied by a change in the colour of the chlorophyll, viz. the winter browning of evergreens and the effect of antipyrin on

Chara. Of these, the latter is only very slight and does not, as a matter of fact, perceptibly affect the assimilatory powers of the cell. In the former case the inability to assimilate is, where the browning and decolorization is complete, readily explained by supposing that the absorption of the necessary energy cannot take place, assimilation returning as soon as the necessary pigment is formed and the necessary connection established, which is often whilst the plant is still quite yellow. What is certain is that the chlorophyll bodies, being living plasma organs, are, like all living plasma, liable by various disturbing influences to an arrest of certain functions, in this case more especially of assimilation. Such functional derangement is possible with and without visible alteration in either the colour or structure of the chlorophyll grain. In this respect the absorption or non-absorption of light is of only secondary importance, for chlorophyll grains of normal appearance and showing normal absorption may be temporarily inactive.

The question as to whether an isolated chlorophyll body can assimilate and evolve oxygen is, in this connection, of much interest. Engelmann * states that single isolated chlorophyll bodies continue, if exposed to light, to assimilate and evolve oxygen, but gives no further details beyond stating that it is shown by the chlorophyll grains of many plant-cells, and that in water the chlorophyll grain swells and bursts and the evolution of oxygen ceases. In one case given, viz. *Hydra viridis*, we have to do not with chlorophyll grains but with Zoochloranthellæ, modified endophytic algal cells, according to Brandt †. Haberlandt ‡, however, found that in *Funaria hygrometrica* isolated chlorophyll grains continue to assimilate and evolve oxygen (Bacterium method) in a 25-per-cent. solution of cane-sugar, but does not state how long the power of assimilation is retained. His experiments are also open to the serious objection that in a 25-per-cent. solution of sugar *B. Termo* is plasmolysed and almost entirely ceases to move. The explanation probably is that, in making the preparations, the sugar solution was diluted

* Engelmann, "Neue Methode zur Untersuchung der Sauerstoffanscheidung pflanzlicher und thierischer Organismen," in Bot. Zeit. 1881, p. 446.

† Brandt, in Monatsber. d. Berlin. Akad. 1881, p. 388.

‡ Haberlandt, 'Ueber die Beziehungen zwischen Function und Lage des Zellkernes,' 1887, p. 117.

down to 15 per cent. or 20 per cent., in which *B. Termo* continues to move actively.

The method adopted is to cut sections with a sharp razor in sugar solution, when, on removing the sections, many uninjured chlorophyll grains are left behind. To this fluid Bacteria, taken fresh from a pure culture on the point of a sterilized platinum wire, are added, and the cell is then closed. The less manipulation the better, no pressure from the cover-glass is allowable, air-bubbles must be totally absent, the Bacteria must be from young and perfectly pure cultures, the sugar solution filtered and sterilized, and the leaves carefully washed and brushed in sterilized water. Otherwise, preparations from moss-leaves often contain unicellular algæ, which naturally show active assimilation, and which are in some cases rather like chlorophyll grains and apt at first to be mistaken for them, being surrounded by a cell-wall of extreme tenuity. When we consider to what severe treatment the chlorophyll grains must necessarily be subjected in order to procure its isolation, and under what abnormal conditions it then is, it is not surprising to find that the majority of the plants experimented with, including *Chara*, *Nitella*, *Oxalis*, *Ilex*, &c., gave negative results. In *Oxalis* the acidity of the liberated cell-sap probably injuriously affects the chlorophyll grain, and this may to a greater or less extent often be the case. The cases in which definite results were obtained are arranged for convenience in tabular form :—

Catharinea undulata.	Weak assimilation in 10 p. c. sugar, stronger in 15 p. c. In 1 to 3 hours the evolution of oxygen begins to weaken and in 3 to 5 hours ceases. In 1 p. c., 2 p. c., 3 p. c., 4 p. c., or 5 p. c. KNO_3 solution no power of assimilation is shown.
Funaria hygrometrica.	In 10 p. c. and 15 p. c. many chlorophyll grains show weak but distinct assimilation, which in 1–2 hours weakens and in 3–5 hours ceases. Similar results with the chlorophyll grains of the sporogonium, but being smaller the evolution of O is correspondingly weaker. [Any spores present show a distinct evolution of oxygen when in the young green chlorophyll containing condition, but this becomes weaker as the spores grow older, and the chlorophyll alters and finally ceases.]
Dicranum scoparium.	In 5 p. c. and 10 p. c. cane-sugar very weak assimilation is shown in many chlorophyll grains, but in 1 hour this begins to weaken, and in 2–3 hours none is perceptible.

Table (*continued*).

Vallisneria spiralis.	In Pfeffer's Nahrlosung (15 times concentrated) weak but distinct evolution of O from many chlorophyll grains in light, ceasing in darkness, but power of assimilation is soon lost. In 4 to 5 p. c. cane-sugar evolution of O almost imperceptible and soon ceases. In 10 p. c. cane-sugar, distinct but weak assimilation in many cases, which after 3 hours begins to weaken, and in 4 to 6 hours has entirely ceased.
Selaginella helvetica.	Both large and small chlorophyll grains may show evolution of O, former when uninjured better than the latter, owing to their larger size. At best never more than $\frac{1}{2}$ to $\frac{1}{3}$ the activity of the evolution of O from an algal cell of the same size. In 15 p. c. sugar solution in many cases assimilation still quite distinct after 5 or 6 hours, and in few cases still present, though much weaker after 10 hours, but the next morning the grains are always dead. In 10 p. c. sugar, the evolution of O is less marked, in 3 hours is very weak, and is shown in only few cases, in 5 hours ceases. In 2 p. c. and 3 p. c. KNO_3 weak evolution of O, which ceases in 2–3 hours, and is present in only relatively very few quite uninjured grains. In 5 p. c. $K_2C_4H_4O_6$, weak evolution of O from most uninjured grains, but in 1–2 hours ceases.

The evolution of oxygen very rarely approaches in strength to that shown by an algal cell of similar size and is nearly always much weaker. When the evolution of oxygen is relatively fairly active and the chlorophyll grain is lying free in the fluid, the Bacteria swarming around it may cause it to roll about or twist on one axis from time to time. When it is very weak, a Bacterium lying on or near the chlorophyll grain may be seen to suddenly dart off for a short distance; if the path is short it may return, but if long it may lose itself in the surrounding oxygenless desert and come to rest. This is repeated at intervals by other neighbouring Bacteria.

In darkness the movement entirely stops in a minute or two, and on re-exposure to light is shown again almost at once, recommencing in less time than it takes to cease. The stoppage and recommencement may be repeated many times with the same chlorophyll grain. Young and old, larger and smaller, dividing and non-dividing chlorophyll grains may show the same evolution of oxygen, but naturally it is more marked where the chlorophyll grain is larger. The fact that the evolution of oxygen ceases in the dark and recommences on exposure to light, shows that it is not due to the setting free of loosely combined

oxygen previously present in the chlorophyll grain, nor is the movement of the Bacteria due to the evolution of nutritious substances from the chlorophyll grain, for in a solution of sugar the Bacteria come to rest as soon in the neighbourhood of dying cells or grains as in the open field.

To detect the evolution of oxygen, chlorophyll grains quite free from adhering protoplasm are better than ones to which plasma is attached. The dying but still respiring plasma absorbs oxygen, and this is the case even with the free entire (but fatally affected) cell-contents; such show in sugar solution no evolution of oxygen and no movement of Bacteria in their neighbourhood (previously to examination the plants were in all cases kept for one to a few days in darkness, or semi-darkness). Rarely the complete uninjured cell-contents may be obtained lying free. These show a distinct power of assimilation which may continue for several hours, and in a few cases for more than a day.

In the cell with Bacteria the chlorophyll grains may die because of the abnormal conditions (absence of oxygen, presence of Bacteria) to which they are exposed in the closed cell. Preparations of chlorophyll grains, however, kept in a hanging drop of sugar solution in a dark chamber for several hours are found to show no evolution of oxygen on examination; *i. e.* the chlorophyll grains are either unable to recover from the shock of removal and isolation, or are incapable of continuing a separate existence apart from the cell to which they belong for longer than a few hours, their autonomy being only partial and incomplete.

In other media than sugar solution similar or worse results are given. Sugar solution + 1 per cent. peptone or with a little gum arabic gives similar results to sugar solution alone, whilst the viscidity of egg-albumin stops or so retards the movement of the Bacteria as to prevent its being used as a medium.

In *Selaginella*, owing to the plants having been previously kept in the darkness for 2 or 3 days, the chlorophyll grains show no perceptible starch. The isolated chlorophyll grains, after showing 10 hours' assimilation, on staining with iodine show very minute granules of starch, but not always. These might, however, have been originally present, but invisible until stained, or might be formed from the sugar solution in which the grain lies. In preparations kept in darkness for the same time, however, no formation of starch can be detected. In *Vallisneria* a similar

formation of starch can apparently be detected if, as rarely happens, the chlorophyll grains assimilate for longer than 4 hours, but the grains are excessively minute and still more doubtfully the result of the assimilation of the chlorophyll grains after isolation.

In *Elodea canadensis* the externally isolated chlorophyll grains show no power of assimilation. If leaf strips are plasmolysed in strong sugar solution and then examined in 15 per cent. to 20 per cent. sugar solution + Bacteria, the shrunken cell-contents do not perceptibly re-expand, but show a distinct though not strong evolution of oxygen. In some cells, at one end or corner 2 or 3 chlorophyll bodies or even single ones may be isolated, and from these a weak but distinct evolution of oxygen can be detected if the plasmolysed bodies of the neighbouring cells are sufficiently distant, and if the chlorophyll grains are adhering to the upper side of the cell-wall. In some cases such isolated chlorophyll grain or grains can be seen to have a little plasma associated with them, or to have plasmatic connections, but in other cases appear to be perfectly free from plasma and to be without any fibrillar connection with the rest of the cell contents, and nevertheless retain the power of assimilating and evolving oxygen.

It appears, therefore, that in certain cases an isolated chlorophyll grain can continue to assimilate, but is incapable of an independent life, ceasing to assimilate, and dying within a few hours after removal from the parent cell.

The above fact does not in any way support the hypothesis that the chlorophyll bodies of higher green plants are phylogenetically to be regarded as endophytic symbiotic algal cells which have completely or almost completely lost their autonomy, but is rather comparable with similar cases known in animal physiology (Frog's heart or sartorius or gastrocnemius muscle), where an isolated organ of considerable physiological complexity may remain living and functionally active for many hours, or even a couple of days, after removal from the parent body.

Cases in which in adult cells, after a destruction of the "primary" chlorophyll grains, a new formation of "secondary" chlorophyll grains takes place are not definitely established. Thus Schimper has shown that, in the winter browning of evergreens, it is only when the chlorophyll bodies remain intact that

the cells can recover and become green again. Similarly the secondary chlorophyll grains which Dehnecke (*l. c.*) describes as appearing in many cases after the primary chlorophyll grains, loaded with starch, have lost their starch, disintegrated and disappeared, are either formed from the latter or are simply the same grains in a different condition. On the other hand, the fact that in young cells and organs chlorophyll corpuscles may be formed and differentiated where none were previously present (Schimper)*, is proof positive that the chlorophyll corpuscle is simply a specially modified and differentiated portion of the protoplasm of the cell, resembling the nucleus somewhat in the structure and nature of its plasma and in being bounded (according to some authors) by a distinct limiting membrane, but differing in its infiltration with chlorophyll and in being specially differentiated to form the centre or focus for the process of assimilation.

Though the chlorophyll body is specialized simply and solely for assimilation, it does not follow that this function will not be affected by changes in, or by causes influencing, the general protoplasm of the cell. It is only the first stages of plant assimilation which are restricted to the chlorophyll body, those which consist in the conversion of simple inorganic compounds (water and CO_2) into more complex and organic compounds (sugar and starch); the final processes of assimilation, in which dead organic or inorganic compounds are built up into living protoplasm, are carried on by the general protoplasm of every cell, whether animal or plant. Any cause which acts upon the general cell protoplasm and stops or hinders either the later stages of assimilation or the removal of the accumulated assimilatory products, will also react upon the first stages of assimilation, *i. e.* assimilation by the chlorophyll body, hindering or stopping this also. Thus Saposchnikoff* has shown by experiments with cut leaves of *Vitis* and *Rubus*, that when the carbohydrates present reach a certain percentage no more are produced. In *Vitis Labrusca*

* A. F. W. Schimper, "Untersuchungen über die Chlorophyllkörper," in Pringsh. Jahrb. Bd. xvi. 1885.

† W. Saposchnikoff, "Ueber die Grenzen der Anhäufung der Kohlenhydrate in den Blättern der Weinrebe und anderen Pflanzen," in Ber. d. D. Bot. Ges. Bd. ix. 1891, p. 293. Also preceding papers in 1890 and 1889, p. 258 and p. 233.

this takes place when the amount of carbohydrate (starch and sugar) reaches from 17 per cent. to 25 per cent. the dry weight of the leaf. As soon as a leaf-cell contains 2 per cent. of sugar the conversion of this into starch commences, but when the amount of starch has reached its maximum, the leaf-cell still continues to assimilate until it contains sugar of from 6-per-cent. to 8-per-cent. concentration, and is no longer plasmolysable by a 10-per-cent. solution of glycose.

In a later paper Saposchnikoff * finds that isolated leaves of *Vitis vinifera*, after 6 to 7 days' exposure to light, can form no more carbohydrates, and then contain of carbohydrates 23 per cent. to 29 per cent. of the dry weight of the leaf, there being very little difference between the results given by leaves with their stalks in distilled water and others with their stalks in a nutrient solution. If the leaves are kept in an atmosphere containing at the commencement 20 per cent of CO_2, in 3 days the maximal accumulation of carbohydrates is produced, and this is from 30 per cent. to 35 per cent. of the dry substance of the leaf, this greater amount being probably due to the leaf remaining more normal in the shorter time of exposure.

If the accumulation of carbohydrates eventually causes a stoppage of assimilation, it must also involve a cessation of all evolution of oxygen. Hence the Bacterium method affords a ready means of confirming and extending Saposchnikoff's observations, especially as regards the recovery or non-recovery of assimilation on the diminution or removal of the accumulated carbohydrates.

Effect of the Accumulation of the Assimilatory products (Carbohydrates) upon Assimilation.

The adult leaves cut with the upper part of the petiole attached are kept with their stalks in water exposed to the brightest diffuse light, but shielded from too intense and prolonged sunlight.

* "Beitrag zur Kenntniss der Grenzen der Anhäufung vom Kohlenhydraten in den Blättern," in Ber. d. D. Bot. Ges. Bd. xi. 1893, p. 391.

Rubus odoratus.	After 10 days the leaves show distinct but weak evolution of O, and contain abundance of starch. If then kept for 2–3 days in darkness at 30° C., a distinct diminution of the starch and a moderately active evolution of O are shown. After 15 days the leaves are yellowish in parts, but even the normal green parts show no evolution of O, and the starch is very abundant. If kept in darkness for 3 days at 30° C., all the leaves which remain normal and living show a fairly active evolution of O and a marked diminution of the amount of starch present.
Vitis vinifera and *Vitis Labrusca.*	After 10 days a weak evolution of O is still shown, but in parts none. After 12 days no evolution of O, the cells are loaded with starch, but the chlorophyll grains are otherwise normal. After 3 days in darkness at 30° C., a fairly active evolution of O is shown in all cases and the starch is distinctly diminished in amount.
Æsculus Hippocastaneum.	After 7 days evolution of O is quite weak. After 10 days the mesophyll at bases of leaflets in parts turns yellow, rest of leaf green and normal, but no evolution of O. In darkness for 3 days at 30° C., the greater part of the leaf remains green and shows a moderately active evolution of O, the starch being distinctly reduced in quantity.

It is not always possible to secure a return of assimilation by keeping the plants in darkness and allowing the respiratory activity of the leaf-tissues to use up a certain amount of the accumulated carbohydrate, and permit a resumption of assimilation, for the leaf may have been so injuriously affected by the treatment to which it has been subjected, that it may die when kept in darkness without any appreciable amount of carbohydrate being removed or any return of assimilation taking place.

In an atmosphere containing a large, but not too large, percentage of CO_2, since assimilation goes on more actively, it is natural to expect that in the isolated leaf the maximal accumulation of carbohydrates and consequent stoppage of assimilation will take place with much greater rapidity than in ordinary air. Thus adult leaves of *Vitis vinifera* and *V. Labrusca* were exposed as previously, but in a bell-jar in an atmosphere containing 10 per cent. of CO_2, renewed daily, the plants being shielded from too intense sunlight, and the temperature within the bell-jar never being allowed to rise above 30° C. At the end of 3 days the leaves still show in parts a weak evolution of oxygen, but in parts none. After 4 days the leaves are quite green and normal, but the cells are loaded with starch and no evolution of

oxygen is shown. After being kept in darkness for 3 days at 30° C., the leaves are still green and normal in appearance, there is a marked diminution in the amount of starch present, and a fairly active evolution of oxygen is shown when exposed to light. That the more rapid stoppage of assimilation is due simply to the more rapid accumulation of carbohydrates, and not to any poisonous depressant influence of the CO_2, is shown by the fact that leaves of *Vitis vinifera* and *V. Labrusca* kept in an atmosphere containing 10 per cent. of CO_2, but exposed to very weak diffuse daylight, show after 4 days no perceptible accumulation of starch and an active evolution of oxygen on examination.

In experimenting with Mosses, it is practically impossible, if the entire plants are used and kept in ordinary air, by even full and prolonged exposure to light to cause a maximal accumulation of carbohydrates and consequent stoppage of assimilation, for the starch and sugar are being continually transferred to the growing parts and used there for the formation of proteid and cellulose. If, however, the young growing apices are removed and plants kept stuck through thin slips of cork floating on water, isolated from one another, fully exposed to light, and in an atmosphere containing from 10 per cent. to 15 per cent. of CO_2, quite definite results are obtained. Thus after 5–6 days exposure the leaves all remain living, but show no evolution of oxygen (*Dicranum scoparium*, *Catharinea undulata*, *Bryum cæspititium*, *Mnium stellare*). In *Catharinea* the cells are quite granular, with starch grains both enclosed in the chlorophyll grains and lying free in the protoplasm. In *Bryum* the chlorophyll grains are swollen with one or more centrally placed starch grains, and abut on one another so as to be polyhedral instead of spherical as normally. In *Mnium* the protoplasm is finely granular, but the granules do not stain with iodine. Starch is present only in the chlorophyll corpuscle and in the form of a single large central grain. In *Dicranum* the protoplasm is granular, opaque, and contains an abundance of oil, whilst each chlorophyll grain contains a rather small but distinct starch grain, commonly absent from normal plants. Here starch appears only to be formed when an excess of oil and sugar are present. After the plants have been kept for 1 day in darkness at 30° C. in a damp well-aerated atmosphere, a weak power of assimilation is shown by most leaves of *Mnium* and *Bryum*, at the bases of the leaves in *Catharinea*, and in the younger leaves

of *Dicranum*, though no perceptible diminution of the stored starch has taken place. After 3 days a fairly active power of assimilation is shown by all living leaves, and a perceptible diminution in the amount of starch present has taken place. If the same experiment be repeated with entire plants, after 8 days nearly all adult leaves can no longer assimilate, but the young apical leaves still show a weak to fairly active power of assimilation.

Experiments with *Allium Cepa* are interesting, because in this plant the superfluous carbohydrate is stored not in the form of starch but of sugar. The leaves of *Allium* die rather readily when separated, and hence form unfavourable experimental material, but if the fully-developed flowering axis be cut off at its base, and the flower-head removed, the axis may remain living for weeks if the basal end be kept in water. Fehling's test shows that in such a fresh flowering-axis traces of sugar are present in the outer assimilating layers, but much more in the inner parenchyma and abundance in the basal $\frac{1}{6}$th to $\frac{1}{10}$th of the axis. After being exposed to bright light for 8 days (base in weak sugar solution) or 14 days (base in water), sugar is present in all cells and tissues and only a weak power of assimilation is shown. After 10 days (base in sugar) or 14 days (base in water) all the cells are rich in sugar, and no evolution of oxygen is shown, though the cells are normal in appearance and the chlorophyll grains quite green and unaffected. After 2 days in darkness at 30° C. a very weak power of assimilation is shown, and plenty of sugar is still present in the inner parenchyma, but much less in the outer green assimilating layers. After 4 days assimilation is moderately active, and a little sugar is still present in the outer assimilating layers, but more in the inner parenchyma.

Plants of *Œdogonium* kept in water through which CO_2 is occasionally allowed to slowly bubble, and exposed for several days to bright diffuse daylight, become packed with starch and show no power of assimilating except in a few cells, chiefly at the growing ends of the filaments, but also in intercalary cells, which contain much less starch, and show a moderately active evolution of oxygen. If the plants are now kept in darkness in well-aerated water at 20° C., after 5 days many filaments die, but most remain living, show a distinct reduction in the amount of starch present, and a fairly strong power of assimilation.

With most water-plants it is difficult to cause the maximal accumulation of carbohydrates to take place, but if plants of *Elodea canadensis* and *Utricularia vulgaris* are kept exposed to bright light in a frequently renewed 5-per-cent. solution of grape-sugar, in many of the older leaves or branchlets a marked accumulation of starch takes place and the power of assimilation is correspondingly weakened, in some cases none being perceptible. If moss-plants (*Dicranum scoparium*, *Bryum cæspititium*) are kept partly immersed in a 5-per-cent. solution of grape-sugar, and exposed to bright light, a maximal accumulation of carbohydrates and a consequent cessation of assimilation until the amount is reduced, is readily produced in the older adult leaves.

Since Saposchnikoff has shown that in isolated leaves of *Vitis*, when the further formation of carbohydrates ceases, the amount of sugar present in the cell-sap may reach in strength that of a 10-per-cent. solution, it might be expected that mere immersal in such a solution of sugar would cause a stoppage of assimilation. Klebs * has, however, shown that various Algæ and even Mosses (*Funaria*) cultivated in 20-per-cent. cane-sugar or 10-per-cent. glucose may, though plasmolysed, form a new cell-wall and starch grains, but his experiments are not conclusive as to whether the plants actually assimilated or merely converted absorbed sugar into starch. To settle this point, direct observations by the Bacterium method were necessary. As regards the movement of the test Bacteria in strong solutions of sugar, &c., Fischer † has shown that *Spirillum* shows in 1-per-cent. KNO_3 or 5-per-cent. cane-sugar weak plasmolysis in a few cases, in 2-per-cent. KNO_3 or 10-per-cent. cane-sugar strong plasmolysis in nearly all cases, and very strong plasmolysis in 5-per-cent. KNO_3 or 30-per-cent. cane-sugar, whilst in water the Bacterial protoplasm re-expands and the Bacteria become homogeneous again. The movement of the Bacteria ceases only when they are strongly plasmolysed. Beyond stating that *Bacterium Termo* (*Bactrillum Pseudotermo*) is strongly plasmolysed by a 2½-per-cent. solution of KNO_3, and that in almost any nourishing solution it retains the power of movement, even in a very weak acid culture in which other Bacteria lose the power of movement, no

* G. Klebs, "Beiträge zur Physiologie der Pflanzenzellen," in Tübingen, Bot. Untersuch. Bd. ii. Hft. 3, 1888, pp. 500–537.

† Alfred Fischer, "Untersuchungen über Bakterien," in Pringsh. Jahrb. Bd. xxvii. 1895, pp. 9, 31.

further information is given concerning the persistence of the power of movement in this form.

Actual observation shows that the movement of *Bacterium Termo* remains quite active in 1-per-cent. KNO_3, 10-per-cent. cane-sugar, or 5-per-cent. grape-sugar; in 2½-per-cent. KNO_3, 20-per-cent. cane-sugar, and 10-per-cent. grape-sugar, fewer Bacteria move and the movement is slower; in 3-per-cent. KNO_3, 25-per-cent. cane and 15-per-cent. grape sugar, a few Bacteria still show distinct but slow translatory movement, but only a very slight attraction to air-bubbles; in 5-per-cent. KNO_3, 30-per-cent. cane-sugar and 20-per-cent. grape-sugar, all translatory movement ceases. If the Bacteria have been kept in ordinary sterilized tap-water for 2–3 hours, they show almost undiminished activity of movement, but now in a 20-per-cent. solution of cane-sugar, instead of a 30-per-cent. solution as with Bacteria fresh from Agar-tube cultures, all movement at once ceases. If sterilized solutions of cane and grape sugar, 10-per-cent., 20-per-cent., 30-per-cent., and 40-per-cent., are inoculated with *B. Termo*, either the cultures do not develop, or, if they do, the Bacteria are all immotile forms and show no movement even when the solutions are diluted down to 5 per cent. Hence, though the ability of the Bacterium to retain its power of movement in strong solutions of sugar is weakened when kept for a few hours in water, the converse does not hold, for cultures made in strong sugar solutions show no power of movement at all.

It is possible, however, to conduct accurate direct observations by the Bacterium method upon the absence or persistence of assimilation in solutions of 10-per-cent. to 15-per-cent. grape-sugar or in 20-per-cent. grape-sugar.

Experiments with *Elodea*, *Utricularia*, *Bryum*, *Funaria*, and *Allium* show that in solutions of these strengths the power of assimilation remains fairly active as long as the cells are living, though in *Elodea* the cells may be completely plasmolysed, the plasmolysis being less marked in *Bryum* and *Funaria*, still less in *Allium*, and not at all in *Utricularia*. Assimilation is naturally not so active in a 20-per-cent. solution of cane-sugar as it is normally, but the weakening is probably simply due to physical causes, viz. the withdrawal of water and the lessened exposure of the chlorophyll grains in the plasmolysed condition. It does not follow that because cells are immersed in a strong sugar solution that therefore the cell-sap will contain a similar percentage of sugar and thereby cause, if sufficiently concentrated, a stoppage

of assimilation. The primordial utricle in all cases determines at what rate and in what quantity any given substance will pass through to the cell-sap. Immersion in a weak sugar solution helps to produce the maximal accumulation of carbohydrates more rapidly only because it affords another source from which carbohydrate material is drawn, and not because of any physical diffusion through the primordial utricle and accumulation in the cell-sap.

Immersion in very strong sugar solution causes so marked a withdrawal of water as to affect the power of assimilation, and finally the vitality of the cell. The plants are placed in solutions of gradually increasing strength until the desired percentage is reached, when, after a few hours' immersion, preparations are examined in a 20-per-cent. solution of cane-sugar with Bacteria. After being for half an hour in 20-per-cent. and the same time in 10-per-cent., the plants are placed in water.

Elodea canadensis.	After 3–4 hours in 35 p. c. or 6–8 hours in 30 p. c. of cane-sugar shows, when examined in 20 p. c., no power of assimilation, though most cells remain living. In 10 p. c. a weak evolution of O is shown in most cases, which after 1–2 hours in water becomes normal.
Catharinea undulata; *Dicranum scoparium.*	After 12 hours in 35 p. c. or 24 hours in 30 p. c. no evolution of oxygen is shown under optimal illumination. Recovery as in *Elodea.*
Bryum cæspititium; *Grimmia conferta*; *Orthotrichum affine.*	After 1 day in 35 p. c., show in 20 p. c. no evolution of O, but assimilation returns on accustoming to water, and becomes normal in a few hours. After 1 day in 30 p. c., show in 20 p. c. weak evolution of O in many cases, but in most cases none. After 2 days in 30 p. c. some leaf-cells die; rest show no evolution of O. On accustoming to water a weak evolution of O is shown, which in 1 day is fairly active in all living cells.

In all cases it is impossible to produce a complete temporary stoppage of the power of assimilation without killing a few leaves or leaf-cells, though most remain living and recover. The different times necessary for the stoppage of assimilation to take place are probably due to differences in the permeability of the cell-wall and in the force with which the cell retains water. Thus *Elodea* is very readily plasmolysed, but *Catharinea* and *Dicranum* much less readily, and *Bryum* and *Grimmia* least readily. When the concentration of the cell-sap reaches a percentage equivalent to 35 per cent. of sugar, assimilation soon

ceases (external action); but, according to Saposchnikoff, in Phanerogams, when sugar accumulates in the cell-sap as a product of assimilatory activity, as soon as the latter contains 8 per cent. of glucose further assimilation ceases (internal action).

The stoppage of assimilation which occurs when the maximal accumulation of carbohydrates is reached, is undoubtedly largely due to the fact that the sugar can no longer be converted into starch and accumulates in the cell-sap till the assimilatory limit is reached, but is also partly a direct effect of the accumulation of starch in the chlorophyll grain, for, as will be seen later, in certain cases, under circumstances in which no large amount of sugar can be present, an excessive deposit of starch in the chlorophyll grain is accompanied by a cessation of the power of assimilation. Dehnecke came to the conclusion, from the well-known fact that in many chlorophyll grains a large deposit of starch may take place, though the amount of assimilation they can possibly have carried on can only have been trifling, that green chlorophyll grains, which have as their sole function that of a leucoplastid and have no power of assimilating, are of common occurrence in green plants.

Pellionia Daveauana affords very good material for testing the truth of Dehnecke's conclusions. In the stem of this plant the parenchyma-cells contain special small amyliferous chlorophyll grains. In the young stems and petioles the chlorophyll grains in the outer half of the stem contain little or no starch; the central cells are larger, and in them each chlorophyll grain forms a green plate or flattened cap on the end of a large starch grain. The chlorophyll grains are, when without starch, round and about $\frac{1}{3}$ to $\frac{1}{2}$ the size of those of the leaf mesophyll, and each cell of the stem parenchyma contains from six to a dozen. The outer cells of the stem contain about $\frac{1}{15}$ to $\frac{1}{20}$ the amount of chlorophyll that the leaf-cells do. Nevertheless, from them on exposure to light a weak evolution of oxygen can be detected, but none from the inner starch-loaded cells. In the older basal parts of the stem all the parenchyma is amyliferous, the starch grains being much larger and almost entirely filling up the cavity of the cell. Here no power of assimilation can be detected.

The question is, whether with the removal of the starch the power of assimilation returns to these leucoplastic chlorophyll grains. To remove the starch, the plants may either be kept in the darkness or exposed to light in an atmosphere free of CO_2. In the latter case, after 10 days' exposure at 20° C. to 25° C.,

starch is still present in the cells immediately around the vascular bundles, but the grains are more or less corroded and lessened in number. Here no evolution of oxygen is shown, but in some of the outer parts of the stem a very weak power of assimilation can be detected. After longer exposure all the green parts, including the leaves, lose the power of assimilation, and the plants finally die without any further marked decrease in the amount of starch present taking place.

The most effective mode of removing the starch, which shall at the same time cause the least possible injurious influence, is to keep the plant at a fairly high temperature exposed to extremely weak diffuse daylight in an abundant and frequently-renewed supply of moist air. After being under such conditions for 3 weeks, or in darkness for 2 weeks at 30° C., the plants are quite healthy, starch has entirely disappeared, the chlorophyll grains of the stem are quite normal, round, green, and show, if examined after a few hours' exposure to light, a moderately active evolution of oxygen, which is normal for the amount of chlorophyll present.

If the stems are examined after a day or two in darkness, the starch grains show as yet no signs of dissolution, and the amount of sugar present in the cells must be very small, but no power of assimilation is shown. The stoppage of assimilation in these leucoplastic chlorophyll grains is due simply to the accumulation of starch; they retain a potential power of assimilation which is capable of being exercised as soon as the inhibitory influence exercised by the deposited starch is removed.

In all the cases in which Dehnecke concluded that non-assimilatory chlorophyll grains having solely the function of amyloplasts were present (pith of *Phaseolus* and *Pisum*, chlorophyllaceous cotyledons, &c.), it is only when the chlorophyll grain is overloaded with starch that any stoppage of the power of assimilation takes place. He cites Hanstein's observations upon the amyliferous chlorophyll grains of the medullary cells of *Chara*, and Sachs upon the chlorophyll "Bläschen" in the flesh of fruits as proving that the chlorophyll grains in these cases also are non-assimilatory. The medullary cells of *Chara* have, however, been shown (pp. 417, 439) to possess a power of active assimilation. If tangential sections from the young green fruits of *Pyrus baccata* and *P. Torringo*—through the outside layers in which the chlorophyll grains are abundant, green, and normal—are examined, they are found to show a distinct though

not strong evolution of oxygen when exposed to light. As soon as the chlorophyll grains are loaded with starch and when converted into "Bläschen" or disintegrated they naturally cease to assimilate. Dehnecke erred in supposing that amyliferous leucoplastic chlorophyll grains never could assimilate; the stoppage of assimilation is more accidental than functional, and in many cases of merely temporary duration.

In many young stems the chlorophyll grains are found in the form of thin green envelopes enclosing one or more starch grains. These are, according to Dehnecke, non-assimilatory chlorophyll grains from which the starch grains finally escape, leaving the thin green envelope as a chlorophyll "Bläschen," which finally disappears, new secondary chlorophyll grains being formed by protoplasmic differentiation. In investigations of this kind the effects of manipulation and section-cutting are liable to form a serious source of error, for the latter especially may cause sections of living tissue to show chlorophyll grains as "Bläschen" which were originally in the intact tissue perfectly normal (see p. 390). When, after the starch disappears, new normal chlorophyll grains are seen, these are not new formations produced by protoplasmic differentiation, but are formed from the original starch-bearing chlorophyll grains. Thus in the living uninjured cells it can commonly be seen that one side of the "Bläschen" is thicker and distinctly green. In other cases this thickening forms a distinct but irregularly-shaped chlorophyll grain, which can finally be seen without any starch-enclosing envelope, but with the impression of where a starch grain has previously been on its inner concave surface. In *Pellionia* the amyliferous chlorophyll grains of the stem are reduced to thin, flattened, green plates, which are often almost invisible, but when the starch is removed they become round, normal, green, assimilating chloroplastids. The "primary" and "secondary" chlorophyll grains are therefore simply two different conditions of the same chloroplastid. In fruits, after the starch grains have been converted into sugar the chlorophyll "Bläschen" finally disintegrate, but in all cases where normal chlorophyll grains appear after the disappearance of the starch they are formed from chloroplastids previously present. The initial power of forming chloroplastids by protoplasmic differentiation seems to be present only in the embryonic condition of the cell and to be lost in post-embryonic and adult life.

Effects of Insolation upon Assimilation.

It is well known that prolonged exposure to direct sunlight is fatal to Bacteria and many Algæ, and exercises a marked injurious influence upon many shade-loving and water-plants. Even the most resistant of Phanerogams are, especially at certain periods of development, unable to stand prolonged and severe exposure with impunity. Before the vitality of the plant is permanently affected, there appears to be an intermediate condition from which perfect recovery is possible, but during which the power of assimilation is in abeyance though the chlorophyll apparatus is green and intact. Experiments in this direction were performed on both water- and land-plants, the chief obstacle being the difficulty of obtaining sufficiently long periods of exposure to produce the desired effect.

Plants of *Elodea, Utricularia*, and *Chara* exposed to full sunlight in water kept cool by constant renewal from 5 A.M. to 5 P.M., during a bright unclouded day, gave the following results:—

Elodea canadensis.	Nearly all leaves and leaf-cells living and green; in most cases weak assimilation, but in many leaves, though all cells are living, none. After 2 hours in diffuse daylight, all living leaves show a more or less active assimilation.
Utricularia vulgaris.	All plants living and showing weak assimilation, which is, however, absent from many branches. After 2 hours in diffuse light, fairly active assimilation in all cases.
Chara fragilis.	Many cortical and end cells killed and bleached, plenty living, but no assimilation, and rotation absent or slow. In many branches the cortical cells are killed, but the medullary cells remain living and show in 15–30 minutes rapid rotation. If the cortical cells are quite bleached and the medullary chlorophyll grains quite colourless, then the medullary cells die and rotation ceases in a few hours without any return of assimilation taking place; but if the medullary chlorophyll grains retain partly or entirely a greenish coloration, the cell may recover and show, after 3–4 hours in diffuse light, or, where but few grains retain a greenish coloration, only after several days, a distinct evolution of O. In the living end cells rotation is active in 15–30 minutes, and in 1 hour weak assimilation, fairly active in 3. In a few end cells the chlorophyll is more or less bleached, and though rotation may return and continue for from a few hours to several days no return of assimilation takes place, the cells finally dying.

Ringed cell preparations of end cells of *Chara* kept floating on water at about 15° C., exposed to full sunlight for 4 hours, showed neither rotation nor assimilation. After ½ hour in diffuse daylight a faint evolution of oxygen is shown by most end cells, but in some cases still no rotation. In 1 hour the evolution of oxygen is moderately active, but rotation is still slow. In 5 hours both assimilation and rotation are active.

Similar results as regards assimilation were obtained with freshwater Algæ exposed in water kept below 15° C. for 10 hours, the sun being slightly clouded during the first five, but unclouded during the last five hours.

Spirogyra; *Œdogonium.*	Many filaments dead, but plenty living and with unbleached chlorophyll, but no assimilation; none after 2 h. in diffuse light, weak in 5 h., and about normal in all living filaments next day.
Mesocarpus.	All cells killed and bleached. After 4 h. exposure to sunlight plenty of living and normal cells show no assimilation, and mostly none after 2 h. in diffuse light. Next day assimilation is shown by all living cells.

Similarly with shade-loving land-plants after 12 hours' exposure to full sunlight:—

Dicranum scoparium.	Leaves living and green, but assimilation absent entirely or from apical part only, and where present weak. After 2–4 h. in diffuse light, assimilation is active.
Oxalis Acetosella.	Leaflets green and living, but drooping, and in some cases slightly wilted. No assimilation shown. After 1–2 h. in diffuse light faint, and in 2–3 h. fairly active assimilation, and the leaflets have re-expanded. Leaflets shaded in the drooping position may show a weak assimilation, but none if a reflecting mirror has been placed behind them.

The drooping position assumed by the leaflets of *Oxalis* is simply protective; there is no correlation between the assumption of the drooping position and the temporary loss of the power of assimilation. Preparations made at night from the leaves of *Oxalis* when in the drooping nyctitropic position show a normally active power of assimilation, and the same is the case with leaflets of *Mimosa.* The movements performed in assuming the nocturnal nyctitropic position of certain "sleep" plants are not accompanied by any corresponding internal changes or alterations in the power of assimilation. In this respect the sleep of plants is more external and apparent than internal and real.

With sufficiently prolonged exposure stoppages of the power of assimilation can be caused in the leaves of Phanerogamic trees and shrubs.

Pyrus Toringo; *Æsculus flava*; *Ficus elastica*.	Leaves exposed, attached to the parent plant, to full sunlight till 4 P.M. show no assimilation though living, green, and with normal chlorophyll grains. After 2 h. in diffuse light still no assimilation, but next day the same preparations show, if living, a weak but distinct power of assimilation, and fresh preparations made from the same leaves now show a fairly active power of assimilation.

That the stoppage of assimilation is a direct effect of the exposure to sunlight, and is not due to any accumulation of carbohydrates, is shown by the following facts:—(1) On a leaf exposed to bright diffuse daylight no perceptible inhibitory influence is produced, though the actual amount of assimilation must be as great as, if not greater than, in a leaf exposed to full sunlight. (2) The recovery and return of assimilation after insolation will take place in diffuse daylight, and this although the leaf has been separated from the parent plant. (3) After recovery assimilation may remain fairly active for several days in separated leaves kept exposed to diffuse daylight, whereas if the stoppage were due to an excessive accumulation of carbohydrates it should only be weak and should soon cease again; *i. e.* as soon as the amount of sugar &c. removed by respiration during the night is replaced by the renewed assimilation. Nor is the stoppage the result of the heating effect of the sun's rays, for in *Pyrus* and *Æsculus* transpiration suffices to keep the leaf cool during the exposure, and though the thick leaves of *Ficus* may be slightly warmed by the sun's rays, the rise in temperature is only slight and does not approach anywhere near the critical point.

Ulmus scabra var. *pyramidalis*, *Acer tataricum*, and *Fagus sylvatica* var. *atropurpurea* seem to be more resistant than the plants previously mentioned. Attached leaves exposed during a cloudless day to full sunlight till 5 P.M. show a quite distinct but weakened power of assimilation, which is after a few hours' exposure to diffuse light, or, in some cases, not till the next day, quite active. The retention of the power of assimilation in such leaves may be due to the fact that for a considerable portion of the day they have their edges to the sun or are exposed only to oblique illumination. Hence it is seldom that under normal conditions, except in shade-loving plants, that even an entire day's exposure to full sunlight causes anything more than a weakening of assimilation. In young leaves, in which assimi-

lation is not yet fully active and the tissues and cuticle thin and transparent, and in leaves several months old which have passed the zenith of their vitality, a temporary stoppage of assimilation is much more readily produced by a full day's insolation, and the leaves may become paler or even yellowish. In normal adult leaves it is best produced by removing all but one or two leaves from a terminal leafy branch, and keeping the surfaces of these perpendicular to the sun's rays for an entire unclouded day. The leaves remain fresh and green, but assimilation is either weak or absent. After 2–3 hours in weak diffuse light, a faint power of assimilation may be shown in the latter, but generally still none. Next day the separated leaves, kept under a bell-jar, with the petioles in water, show active powers of assimilation.

Quercus pedunculata, *Tilia europæa*, and *Prunus avium*, of temperate plants, and *Griselinia littoralis*, *Bambusa gracilis*, and *Euonymus fimbriata*, of warm temperate and tropical plants, gave similar results. In exposed cut leaves, with their petioles in water, the stoppage is more readily produced; but here the conditions are abnormal, and the leaf may be more or less wilted after a full day's insolation. Also, even when the leaf remains fresh and green, assimilation may be permanently affected, only a weak evolution of oxygen being shown on recovery. In exposed adult leaves, taken from a variety of plants after a full day's sunlight, assimilation was always present though often weak. In nature leaves are exposed to the full force of the sun's perpendicular rays only for a short time daily. A very slight protection is in most cases sufficient to prevent the stoppage of assimilation, such as a slight clouding over of the sun, continuously or at intervals, or covering the leaf with a film of cigarette-paper, or allowing the edge of the leaf to be turned to the sun. Hence in nature a stoppage of assimilation as a direct effect of sunlight is of very rare occurrence in actively assimilating leaves, though a weakening must often be produced.

The stoppage of assimilation is not necessarily associated with any visible change in either the chlorophyll or the plasma. When green leaves are exposed to sunlight the decomposition of chlorophyll goes on more rapidly than its production, though the amount of chlorophyll decomposed is insufficient to cause a change in coloration visible to the naked eye. Keeble * has

* Keeble, "Hanging Foliage of certain Tropical Trees," in Annals of Botany, vol. ix. 1895, pp. 59–93.

shown that young leaves of *Amherstia nobilis* exposed horizontally to full sunlight formed on extraction with alcohol a weaker solution of chlorophyll than shaded leaves or leaves kept in the normal drooping position did.

Pringsheim * has shown that concentrated sunlight exercises an oxydative photo-chemical effect upon plant-cells and chlorophyll, bleaching the latter, and inducing in the cell-plasma a condition of light rigor, finally followed by death.

Thus exposure to concentrated sunlight, precautions being taken to avoid all heating effect, and hence to obtain a purely photo-chemical action, causes the rotation of protoplasm to be slowed, and finally stopped in a condition of light rigor, from which at first recovery is possible, but not later (after 5 to 10 minutes' exposure). It is possible to produce a condition of permanent light rigor, *i. e.* death, in the chlorophyll grains over an exposed region of a cell of *Chara* without affecting the vitality of the cell, *i. e.* the plasma of the chlorophyll grain appears to be more sensitive than the general protoplasm of the cell. Hence the temporary cessation in the power of assimilation of chlorophyllaceous cells, which may be caused by prolonged and continuous exposure to direct sunlight, is probably due to a photo-chemical effect upon the plasma of the chlorophyll grain, producing in it the initial stages of light rigor, associated with a temporary inability to assimilate, the action being similar to the paratonic influence of light upon growth, and the condition induced in the chlorophyllous plasma being perhaps analogous with the condition of immotility which may be produced in the protoplasm of irritable organs by the action of various chemical and physical agencies.

However the hindrance or stoppage of assimilation may be produced, the fact that such may occur as the result of prolonged exposure to direct sunlight gives additional interest to the different means of protection which various plants possess against the action of light. In temperate regions it is only on very rare occasions and under exceptional conditions of exposure that any marked influence upon assimilation is produced in healthy adult leaves, and hence here protective agencies are almost entirely absent. The leaflets of the shade-loving *Oxalis Acetosella*, however, when exposed to sunlight assume a drooping

* Pringsheim, "Zur Theorie der Assimilation, Chlorophyllfunction und Lichtwirkung," in Pringsh. Jahrb. Bd. xii. 1882, pp. 326–344.

position. The more delicate young leaves are very commonly protected either by being shaded by older leaves, or by a hanging position, or by the formation of a red dye. In tropical plants, where the exposure is much more intense, the abundance and importance of the protective agencies is correspondingly increased. In many tropical plants the leaves place themselves obliquely to the sun's most intense perpendicular rays; but most common of all is the formation of a red dye in either the epidermal cells or in the mesophyll cells as well. Johow * has shown that the formation of the red dye is directly due to the action of light, the exposure acting as a stimulus on certain leaves, and causing in them a formation of red dye. In very many cases this irritability disappears as the leaf becomes adult, and the formation of the dye having ceased, that which is already present in the cell is soon decomposed or absorbed. Engelmann † has shown that the red dye allows nearly all the rays absorbed by chlorophyll to pass through, cutting off for the most part only the rays which are of little or no use for assimilation. The greatest absorption takes place in the yellow and yellow-green, and a lesser but still large amount in the blue, the resultant light being red. The amount absorbed by the red sap may amount to $\frac{1}{3}$ or $\frac{1}{2}$ of the incident light, and it is just those rays which, according to Pringsheim, produce the greatest photochemical effect which are thus removed.

Keeble supposes that one use of the red dye may be as a protective influence against the heating effect of intense sunlight. There can be no doubt, however, that transpiration is by far the most important agent in keeping the leaf at a low temperature; and, as Keeble himself shows, the difference of temperature produced by the presence of the dye is very slight, and does not amount to more than from 1° C. to 2° C. Pick ‡ concludes that certain rays of light hinder the translocation of starch, and that the red dye is of importance in shielding the leaf from such rays. In support of this contention he argues

* Johow, "Ueber die Beziehungen einiger Eigenschaften der Laubblätter zu den Standortsverhältnissen," in Pringsh. Jahrb. Bd. xv. p. 299.

† Engelmann, "Die Farben bunter Laubblätter und ihre Bedeutung für die Zerlegung der Kohlensäure im Lichte," in Bot. Zeit. 1887, Nos. 27 & 28.

‡ Pick, "Ueber die Bedeutung des rothen Farbstoffes bei den Phanerogamen und die Beziehungen desselben zur Stärkewanderung," in Bot. Centralblatt, xvi. pp. 9–12.

that (1) as the red colour disappears and the chlorophyll grains become green, starch becomes more abundant in the chlorophyll grain, because light now exercises its full inhibitory action upon the translocation of starch; (2) young red leaves of *Quercus pedunculata* &c. contain plenty of starch before the chlorophyll grains become green, the starch being derived by excessive translocation from the parent plant, owing to the rays inhibitory to translocation being cut off; and (3) in red light starch is formed in the mesophyll but not in the palisade parenchyma, owing to the red light allowing more rapid translocation from the palisade parenchyma cells. The abundant formation of starch in the chlorophyll grain as it becomes fully adult is simply due to the increased activity of assimilation (see pp. 453–4), and is not in any way related to the disappearance of the red dye, for the same phenomenon is shown by leaves which remain red when adult, provided assimilation is sufficiently active. Similarly with (2), the deposition of starch in young-developing chlorophyll grains is in no way related to the presence of a red-colouring material in the cell-sap, and takes place equally well in young leaves in which all red colour is absent. In (3) the phenomenon is due to the illumination, and hence also the assimilation, being weaker than normal. In such cases sugar does not accumulate in the palisade parenchyma in sufficient amount to reach the starch-forming percentage; but in the mesophyll, especially around the veins, owing to the narrowing of the channel through which it passes, the sugar accumulates, reaches the starch-forming percentage, and starch grains appear in the mesophyll cells.

None of the observations cited by Pick form a certain proof that the special importance of the red dye is due to its cutting off those rays of light which hinder or prevent the translocation of carbohydrates. The function of the red dye seems to be mainly to protect the plasma against the photo-chemical action of strong sunlight. When the red dye is present, as is often the case, over the veins and conducting tissues only, it will, as Johow has shown, by virtue of this protective influence aid translocation in general. Over the assimilatory portion of the leaf, though it appears to exercise a slight protective influence against the heating effect of the sun's rays, and also helps to protect the chlorophyll against the decomposition induced by the action of sunlight, the main function of the red dye is to protect

the assimilatory cells against those rays of light which under intense and prolonged exposure tend to induce in the plasma, more especially of the chlorophyll grain, a condition of light rigor, and thereby diminish or inhibit their power of assimilation.

Assimilation in Parasitic Plants with Normal or Modified Chlorophyll.

Bonnier * has recently worked on the assimilation of green-root parasites as exemplified among the Scrophulariaceæ, and finds that *Melampyrum* can assimilate $\frac{2}{3}$, *Pedicularis* and *Rhinanthus* $\frac{1}{5}$, and yellow-green individuals of *Rhinanthus* and *Bartsia* only $\frac{1}{12}$ the amount of CO_2 that the non-parasitic *Veronica* can. In the last case it is only under strong illumination that assimilation is greater than respiration, whilst in *Euphrasia* and in some plants of *Rhinanthus* and *Bartsia*, even by strong illumination, no evolution of oxygen can be detected. The mere fact, however, that the power of assimilation is much less active in one plant than in another from an allied genus is by no means a sufficient proof that the former plant obtains a portion of its carbohydrates parasitically, but may be simply due to the fact that the amount of carbohydrate material consumed or required is less in the former case than in the latter. The yellow-green individuals of *Rhinanthus* and *Bartsia*, which have almost no power of assimilation, and in which almost complete parasitism is supposed to exist, are in an abnormal condition, and are not fit subjects for experimentation. As regards *Euphrasia*, Bonnier is certainly in error. The chlorophyll grains of this plant are large, green, and normal, and all living chlorophyllaceous cells, not only in *Euphrasia officinalis* but also in *Rhinanthus Crista-galli* and *Bartsia Odontites*, show, on examination by the Bacterium method, an active power of assimilation.

Bonnier's error may arise from the fact that the cut plants kept with their stems in water are very liable to be injuriously affected. Thus after 6 hours' exposure to full sunlight quite unwilted plants show no perceptible or only a very weak power of assimilation, which is, however, after a night in darkness, again present and fairly active in all living leaves. If the plants

* Bonnier, "Sur l'assimilation des plantes parasites à chlorophylle," in Comptes-rendus, Paris, 1891, t. cxiii. p. 1074.

are left *in situ* on the turf from which they are growing, all parts above ground except the *Euphrasia*-stems being removed, and the turf kept moist during the exposure, the conditions are more normal and the plants more resistant; but after a day's exposure to full sunlight, the fully exposed leaves, though green, living, and apparently normal, show none or only a weak power of assimilation.

All cells, whether from parasitic or non-parasitic plants, which contain normal chlorophyll grains possess the power of assimilation, and the intensity of the assimilation bears a direct ratio to the amount of chlorophyll present. The amount of assimilation is of course dependent upon the intensity and duration of the illumination, but is also owing to the fact that the rate at which the assimilatory products are removed exercises an important influence upon the power of assimilation, ultimately dependent upon the special internal structure and vital peculiarities of each individual plant, which are in no two cases precisely similar.

Even in plants in which neither the colour nor the form of the chlorophyll grains is normal, a marked power of assimilation may still be present. Thus Temme * has extracted chlorophyll from *Cuscuta europæa*, though it is only present in relatively small amount. By passing an assimilatory mixture of H and CO_2 over the plants when exposed to sunlight, and using the oxidation of phosphorus as a test for the presence of oxygen, he succeeded in detecting an evolution of oxygen from them. The experiments are, however, not conclusive as to whether the oxygen evolved is produced on exposure to light or was previously present in the tissues of the plant. The green-colouring material, according to Temme, exists partly in the uniformly green plasma, or in separate plasma masses or in grains, this last form being only found in the flower-heads. Detailed and conclusive observations can be made only by means of the Bacterium method, the following being the results thus obtained with *Cuscuta Cephalanti*:—

* Temme, "Ueber das Chlorophyll und die Assimilation der *Cuscuta europæa*," in Ber d. D. Bot. Gesell. 1883, Bd. i. p. 485.

Cuscuta Cephalanti.

1. Young pale-yellow seedlings, a few cm. long. Chlorophyll grains faint greenish yellow. No evolution of oxygen shown in light.

2. Young plants, with well-formed thick coils, with plenty of haustoria. Colour is brownish yellow. Epidermal cells, starch almost entirely absent, chlorophyll grains small and deeply reddish brown, weak evolution of oxygen. Cortex, brownish-yellow chlorophyll grains, starch abundant, frequently 2 or 3 grains to one chlorophyll body; moderately active evolution of oxygen. Inner cortex, chlorophyll grains yellowish green, starch as before; evolution of oxygen slightly more active than from outer cortex.

3. Plants over 3 months old. Chlorophyll grains brownish red. For most part each has formed a group of starch grains, between which the body of the chlorophyll grain is seen only as a reddish-brown matrix. In cells quite packed with starch, generally no power of assimilation can be detected; but where less starch is present (outer parts of older and all parts of younger stems), a weak to moderately active evolution of oxygen is shown. Young buds 0·3 cm. long, from the axils of the scales, contain distinct round small pale yellowish-green chlorophyll bodies; but no evolution of oxygen is shown. When 1 cm. long or more, the chlorophyll grains are yellowish to greenish brown, and show distinct but not strong assimilation.

C. Cephalanti therefore possesses a distinct power of assimilation, which commences as soon as the chlorophyll grains are mature, and continues after all green coloration has been masked by the formation of a reddish-brown pigment, which is probably a derivative of chlorophyll *. Under favourable conditions the bulk of the *Cuscuta* plants was much greater than that of the plants (*Convolvulus*) on which they were parasitic.

* In such cells the nucleus may often be seen to be coloured faintly brownish whilst the cell is still living, and in dead cells the coloration generally deepens. Campbell ("The Staining of Living Nuclei," Arbeit. Bot. Inst. Tübingen, Bd. ii. 1887) has shown that the living nucleus may be stained by certain aniline dyes. The above case is interesting as being an example of a normally stained living nucleus. The shape of the nucleus also is often peculiar; it may be acicular, spindle-shaped, or stalked, with a club-shaped extremity projecting into the lumina of the cell, and the stalk may be longer than the diameter of the cell, in which case it is coiled in one or two turns. The nuclei of *C. europæa* rarely show the same peculiarites of form, but are generally round or oval and normal in shape.

Cuscuta europæa.

(*a*) Young plants 30 to 40 cm. long. Apex is greenish yellow; but chlorophyll grains almost colourless, the apparent deepness of the coloration being due to the transparency of the young tissues. Starch grains few or none. No assimilation. 1st internode: pale greenish yellow; chlorophyll grains faint yellow, more starch; very weak evolution of oxygen. 2nd internode: paler in colour, but chlorophyll grains more deeply greenish yellow; starch abundant; moderately active evolution of oxygen. 3rd internode: red, due to dye in sap of epidermal cells; rest as in 2nd internode. 4th internode: coiled several times round nettle-stem and with plenty of haustoria; starch very abundant, but otherwise as in 2nd internode. The colour of the chlorophyll grains is not very deep, but they are distinct and separate when no, or only one, starch grain is present. When several starch grains are formed, the outline of the chlorophyll grain is generally lost, the group of starch grains appearing simply to be united by a yellowish matrix in which they are imbedded.

(*b*) Stems from adult flowering plants. In outer cortex, less starch, fewer chlorophyll grains, and weak evolution of oxygen. In inner cortex, starch and chlorophyll grains more abundant, and fairly active evolution of oxygen. From cells quite packed with starch, no evolution of oxygen is perceptible. The chlorophyll grains may fuse to form an irregular coloured amyliferous mass, and are rarely spindle-shaped instead of round or oval.

(*c*) Inflorescences. In the outer tissue forming the walls of the anthers normal small green chlorophyll grains are present, and a weak to moderately active assimilation is shown until after dehiscence. In the large cells of the adherent calyx the chlorophyll grains are few in number, but moderately large and distinctly green, and a weak but distinct evolution of oxygen is shown. The central carpellary portion is much greener. The chlorophyll grains have a tendency to fuse to form large green irregular masses with or without starch grains. More than one such mass may be present in the cell, but the rest of the plasma is colourless. Plenty of cells contain quite normal, but somewhat pale green chlorophyll grains. Fairly active evolution of oxygen, whether the grains are single or fused, and with or without starch. From some cells quite packed with starch, the evolution of oxygen is weak or imperceptible.

The power of assimilation exhibited by the chlorophyllaceous stems of *C. europæa* is weaker than in similar green stems of *Convolvulus*, but not more so than would be expected from the less amount and weak intensity of coloration of the chlorophyll bodies. In the chlorophyllaceous parts of the flower the power of assimilation is quite as active, if not more active, than is generally the case in such parts. Wiesner * has shown that in *Neottia Nidus-avis* and in the Orobancheæ distinct chlorophyll

* J. Wiesner, "Untersuchungen über die Farbstoff einiger für chlorophyllfrei gehaltenen Phanerogamen," in Pringsh. Jahrb. Bd. viii. 1872, p. 575.

grains are present, though not in abundance, the green colour of which is often masked by a red or brown pigment. There can be no doubt that these plants also possess a power of assimilation corresponding to the amount of chlorophyll which they contain.

Klebs * describes an interesting condition which may be produced in *Elodea* and *Funaria* as the result of cultivation in a plasmolytic solution of sugar. This consists in a degeneration and, finally, complete disorganization of the chlorophyll bodies, the plants now being reduced to the condition of obligate parasites. In *Funaria* the alteration appears to be due to the presence of a trace (0·05 p. c.) of K_2CrO_4 in the solution of sugar employed; but in *Elodea*, kept in darkness in water, it goes on as actively as in a solution of sugar. In the sugar solution, according to Klebs, the change occurs more rapidly in light than in darkness. It consists primarily in a reduction in size of the chlorophyll grains, these becoming at the same time yellowish in colour. The degenerative changes finally convert the chlorophyll grains into small red dots, to which frequently a small starch grain is attached. From this condition no regeneration appears to be possible; but if the chlorophyll grains are yellow or yellowish brown they may, under proper conditions, recover and become green and normal again. Klebs assumes that this degenerative change is accompanied by a loss of the power of assimilation, an assumption which is not justifiable without direct experimental proof.

The readiest mode of causing the alteration in the chlorophyll grains of *Elodea* was found to be by keeping the plants in well aerated water at 30° C. and in darkness, when, after a week, nearly all leaves and leaf-cells remain living; but the chlorophyll grains are found in all stages of degeneration from quite small brown grains to green and almost unmodified chlorophyll bodies. As soon as the chlorophyll grains begin to diminish in size and turn yellowish green, the power of assimilation becomes very weak. When they are reduced to from $\frac{1}{3}$ to $\frac{1}{2}$ their normal size and have become brownish green, or brownish yellow, the leaf-cells lose all power of evolving oxygen on exposure to light, and this is naturally also the case when the grains are quite small and brown or brownish red. Many leaves show large patches of

* G. Klebs, "Beiträge zur Physiologie der Pflanzenzellen," in Bot. Untersuch. Tübingen, Bd. ii. Hft. 3, 1888, p. 557.

living but non-assimilating cells, in which the chlorophyll grains are but little smaller than normal; and though many have a brown or brownish-green coloration, many are merely yellowish green and more green than yellow. On re-exposure to light, chlorophyll grains reduced to $\frac{1}{3}$ their normal size and quite brown or yellowish brown, became green and of normal size in 10 to 30 days. If the reduction has gone further than this, no recovery or regeneration takes place, and in water such cells soon die, though in a nutrient solution they may remain living for days or even weeks without any further change taking place. As recovery takes place, many cells with chlorophyll grains $\frac{1}{3}$ to $\frac{1}{2}$ normal size, and still quite yellowish brown, may show distinct but weak assimilation; most cells with the chlorophyll grains $\frac{2}{3}$ normal size, and brownish or yellowish green, show a moderately active power of assimilation. The stoppage of the power of assimilation is not merely due to the change in colour of the chlorophyll grains, but is primarily due to some internal invisible alteration, of which the change in the colour of the chlorophyll grain is the outward and visible sign; for on re-exposure to light, a weak power of assimilation may return before any perceptible alteration in either the size or the colour of the chlorophyll grain has taken place.

In plants kept in 20-per-cent. sugar solution the same degenerative changes take place, but only with from $\frac{1}{3}$ to $\frac{1}{4}$ the rapidity under the most favourable conditions with which it occurs in darkness in water. In sugar solution the degenerative changes are much more rapidly produced when the plants are exposed to bright light, with an abundant supply of oxygen, than when kept in the darkness and imperfectly aerated. Under the latter conditions, after two months the chlorophyll grains may be still green and apparently normal, but show no power of assimilation. Under the former conditions, cells in which the chlorophyll grains are reduced from $\frac{1}{3}$ to $\frac{2}{3}$ their normal size and are brownish green in colour, generally show a distinct though weak power of assimilation; but assimilation is always absent when the chlorophyll grains are quite brown and small. The same phenomena of recovery are shown as previously if the plants are accustomed to weaker solutions, and finally to water.

The degenerative changes induced in the chlorophyll bodies by keeping the plants in darkness in water are undoubtedly starvation phenomena, the material used in respiration being supplied

from the integral substance of the cell itself as soon as all reserve carbohydrate, which is never very abundant in actively vegetating *Elodea* plants, is consumed. The same causes which accelerate respiration (fairly high temperature, abundant supply of oxygen, &c.) also hasten the production of the degenerative changes. In sugar solution the change cannot possibly be a phenomenon of starvation, though it may be due to malnutrition of the cell. Very possibly it may be a pathological condition induced by the abundant supply of sugar, the now useless chlorophyll bodies wasting away and degenerating, especially if subject to the changes and decompositions caused by exposure to the action of light.

The Age of the Leaf Cell or Chlorophyll Grain at which Assimilation commences.

The power of assimilation of a chlorophyll grain when once fully formed in an adult cell remains active under normal conditions during the life of the cell, and only begins to diminish when the vitality of the cell is on the wane. The division of a chlorophyll grain, as has already been seen, to form two new grains does not involve any cessation or diminution of the power of assimilation. When, however, the chlorophyll bodies are being formed in a developing tissue, *ab initio*, by protoplasmic differentiation, they are at first colourless and necessarily without any power of assimilation. To determine more exactly the age of the leaf or leaf-cell at which the chlorophyll grains become capable of assimilating, a series of observations were carried out in spring upon the young developing leaves of a variety of plants. When the leaf is thin and the intercellular spaces few and small, a portion of the lamina free from veins may be examined; but in all other cases sections are used. Whenever no power of assimilation can be detected, the observations are repeated. The measurements given are in terms of the largest adult leaf; thus L. $\frac{1}{3}$, B. $\frac{1}{4}$, P. $\frac{1}{9}$ means that the length and breadth of the lamina and the length of the petiole of the young leaf bear to those of the adult leaf these relations. In the first column the measurements are given of the largest leaf in which no power of evolving oxygen can be detected, the subsequent columns tracing assimilation from its first appearance until it is fully active. Where not otherwise stated, the measurements and determinations at any given time are taken from the

	Under optimal illumination. No evolution of Oxygen.	Very weak to rather weak power of Assimilation.	Moderately to fairly active Assimilation.	Quite active assimilation.
Lonicera tatarica	April 14. Leaves yellowish green. L. $\frac{1}{5}$; B. $\frac{1}{6}$; P. $\frac{1}{3}$.	April 19. Still yellowish. L. $\frac{1}{8}$; B. $\frac{1}{9}$.	April 19. L. $\frac{1}{5}$; B. $\frac{1}{6}$.	April 19. Quite green leaves. L. $\frac{1}{4}$; B. $\frac{1}{3}$.
Lonicera alpigena	Ap. 14. Yellowish green. L. $\frac{1}{4}$; B. $\frac{1}{4}$; P. $\frac{3}{5}$.	Ap. 19. Yellowish green. L. $\frac{2}{7}$; B. $\frac{1}{4}$.	Ap. 19. L. $\frac{1}{3}$; B. $\frac{1}{3}$.	Ap. 19. Quite green. L. $\frac{2}{7}$; B. $\frac{1}{2}$; P. $\frac{3}{5}$.
Ribes nigrum	Ap. 14. Yellowish green and partly opened. L. $\frac{1}{6}$; B. $\frac{2}{11}$; P. $\frac{1}{6}$.	Ap. 19. Yellowish green, and partly opened. L. $\frac{1}{9}$; B. $\frac{1}{7}$; P. $\frac{1}{6}$.	Ap. 19. Green and expanded. L. $\frac{1}{9}$; B. $\frac{1}{7}$; P. $\frac{1}{6}$.	Ap. 19. Quite green. L. $\frac{2}{9}$; B. $\frac{3}{11}$; P. $\frac{1}{4}$.
Ribes multiflorum	Ap. 5. Yellowish green and unexpanded. L. $\frac{1}{9}$; B. $\frac{1}{7}$.	Ap. 10. Partially expanded, but yellowish. L. $\frac{1}{4}$; B. $\frac{1}{6}$.	Ap. 15. Expanded and green. L. $\frac{1}{6}$; B. $\frac{1}{5}$.	Ap. 20. L. $\frac{1}{3}$; B. $\frac{2}{7}$.
Spiræa sorbifolia	Ap. 10. Yellowish green. L. $\frac{1}{16}$; Pinnules, L. $\frac{1}{9}$; B. $\frac{1}{10}$.	....	Ap. 15. Quite green. L. $\frac{1}{11}$; Pinnules, L. $\frac{1}{5}$; B. $\frac{1}{7}$.	Ap. 20. L. $\frac{2}{11}$. Pinnules, L. $\frac{1}{3}$; B. $\frac{1}{4}$.
Daphne Mezereum......	Ap. 15. Expanded and yellowish green. L. $\frac{2}{9}$; B. $\frac{1}{5}$.	Ap. 20. From central tuft. L. $\frac{2}{5}$; B. $\frac{1}{4}$.	Ap. 20. Expanded leaves. L. $\frac{1}{3}$; B. $\frac{1}{2}$.	Ap. 24. L. $\frac{1}{2}$; B. $\frac{3}{5}$.
Rosa rugosa	Ap. 15. Green and expanded. L. $\frac{1}{8}$. Pinnules, L. $\frac{1}{11}$; B. $\frac{1}{6}$.	....	Ap. 20. Yellowish. L. $\frac{1}{6}$ Pinnules, L. $\frac{1}{4}$; B. $\frac{1}{3}$.	Ap. 20. L. $\frac{1}{4}$. Pinnules, L. $\frac{3}{11}$; B. $\frac{2}{5}$.
Pyrus prunifolia	Ap. 15. Yellowish green. L. $\frac{1}{6}$; B. $\frac{1}{7}$; P. $\frac{1}{7}$.	Ap. 20. Partially unrolled. L. $\frac{1}{4}$; B. $\frac{2}{11}$.	....	Ap. 20. L. $\frac{1}{4}$; B. $\frac{3}{11}$; P. $\frac{1}{4}$.
Syringa vulgaris	Ap. 20. Slightly yellowish. L. $\frac{1}{5}$; B. $\frac{1}{7}$; P. $\frac{1}{7}$.	Ap. 24. L. $\frac{1}{4}$; B. $\frac{1}{5}$; P. $\frac{1}{4}$.	Ap. 30. L. $\frac{1}{2}$; B. $\frac{1}{2}$; P. $\frac{1}{2}$.	May 4. L. $\frac{1}{2}$; B. $\frac{4}{7}$; P. $\frac{1}{2}$.
Æsculus Hippocastanum.	Ap. 17. Leaves unexpanded. P. $\frac{1}{10}$. Leaflets, L. $\frac{1}{10}$; B. $\frac{1}{8}$.	Ap. 17. Partially expanded. L. $\frac{1}{8}$; B. $\frac{1}{8}$; P. $\frac{1}{8}$.	Ap. 22. Quite expanded. L. $\frac{1}{4}$; B. $\frac{1}{6}$; P. $\frac{1}{3}$.	Ap. 25. L. $\frac{1}{3}$; B. $\frac{1}{4}$; P. $\frac{1}{2}$.
Acer pennsylvanicum.	Ap. 17. Buds partly opened. L. $\frac{1}{20}$; B. $\frac{1}{16}$.	Ap. 22. Leaves partly unrolled. L. $\frac{1}{7}$; B. $\frac{1}{10}$; P. $\frac{1}{8}$.	Ap. 25. Leaves expanded. L. $\frac{1}{4}$; B. $\frac{1}{4}$; P. $\frac{1}{4}$.	Ap. 29. L. $\frac{1}{3}$; B. $\frac{1}{3}$; P. $\frac{1}{2}$.
Salix alba	Ap. 17. Buds just opening. L. $\frac{1}{14}$; B. $\frac{1}{9}$.	Ap. 22. Buds quite opened. L. $\frac{1}{7}$; B. $\frac{1}{4}$.	Ap. 25. L. $\frac{1}{4}$; B. $\frac{4}{9}$.	Ap. 29. L. $\frac{1}{3}$; B. $\frac{1}{2}$.
Tilia pubescens	Ap. 17. Spring bud-scales opened. L. $\frac{1}{11}$.	Ap. 22. Leaves still folded and yellowish, L. $\frac{1}{8}$; B. $\frac{1}{8}$.	Ap. 25. Expanded and green. L. $\frac{1}{6}$; B. $\frac{1}{6}$; P. $\frac{1}{7}$.	Ap. 29. L. $\frac{1}{4}$; B. $\frac{1}{4}$; P. $\frac{1}{5}$.
Magnolia obovata	Ap. 22. Pale yellow. L. $\frac{1}{10}$; B. $\frac{1}{7}$.	Ap. 26. Yellowish green. L. $\frac{1}{7}$; B. $\frac{1}{6}$.	Ap. 30. L. $\frac{1}{3}$; B. $\frac{1}{3}$; P. $\frac{1}{2}$.	May 5. L. $\frac{1}{2}$; B. $\frac{3}{7}$; P. $\frac{1}{1}$.
Diervilla Lonicera......	Ap. 17. L. $\frac{1}{5}$; B. $\frac{1}{6}$; P. $\frac{1}{3}$.	Ap. 22. L. $\frac{1}{4}$; B. $\frac{1}{6}$; P. $\frac{1}{5}$.	....	Ap. 25. L. $\frac{1}{3}$; B. $\frac{1}{2}$; P. $\frac{1}{5}$.

	Under optimal illumination. No evolution of Oxygen.	Very weak o rather weak power of Assimilation.	Moderately to fairly active Assimilation.	Quite active Assimilation.
Larix americana	April 18. Chlorophyll grains very small but green. L. $\frac{1}{7}$.	April 22. L. $\frac{1}{4}$.	April 26. L. $\frac{1}{3}$.	April 29. L. $\frac{1}{2}$.
Salix daphnoides	Ap. 16. Yellowish leaves from central tuft. L. $\frac{1}{12}$; B. $\frac{1}{12}$.	Ap. 20. From apical tuft. L. $\frac{1}{7}$; B. $\frac{1}{7}$.	Ap. 25. Exposed green leaves. From L. $\frac{1}{12}$, B. $\frac{1}{12}$, to L. $\frac{1}{5}$, B. $\frac{1}{5}$.	Ap. 30. L. $\frac{3}{8}$; B. $\frac{3}{8}$.
Corylus Avellana	Ap. 19. Buds open, leaves yellowish and folded. L. $\frac{1}{14}$; B. $\frac{1}{18}$; P. $\frac{2}{15}$.	Ap. 22. Leaves partly expanded. L. $\frac{1}{9}$; B. $\frac{1}{12}$; P. $\frac{2}{15}$.	Ap. 26. Fully expanded. L. $\frac{1}{5}$; B. $\frac{1}{6}$; P. $\frac{1}{3}$.	Ap. 29. L. $\frac{1}{4}$; B. $\frac{1}{3}$; P. $\frac{1}{2}$.
Castanea sativa	Ap. 18. Buds opened, leaves folded. L. $\frac{1}{11}$.	Ap. 22. Leaves partly expanded. L. $\frac{1}{7}$; B. $\frac{1}{6}$; P. $\frac{1}{5}$.	Ap. 26. Quite expanded leaves. L. $\frac{1}{4}$; B. $\frac{1}{5}$.	Ap. 30. L. $\frac{1}{3}$; B. $\frac{1}{2}$; P. $\frac{1}{2}$.
Quercus sessiliflora v. *Louettii.*	Ap. 24. Buds opened, leaves folded. L. $\frac{1}{9}$; B. $\frac{1}{5}$.	Ap. 28. Leaves expanded. L. $\frac{1}{4}$; B. $\frac{1}{5}$; P. $\frac{1}{10}$.	May 4. L. $\frac{1}{3}$; B. $\frac{2}{5}$; P. $\frac{1}{4}$.	May 10. L. $\frac{3}{4}$; B. $\frac{3}{5}$; P. $\frac{1}{7}$.
Betula lenta	Ap. 24. Buds opened, leaves folded. L. $\frac{1}{8}$; B. $\frac{1}{11}$.	Ap. 27. Leaves expanded. L. $\frac{1}{5}$; B. $\frac{1}{8}$; P. $\frac{1}{7}$.	....	Ap. 30. L. $\frac{1}{3}$; B. $\frac{1}{4}$; P. $\frac{1}{4}$.
Populus tremula	Ap. 24. Leaves unexpanded, L. $\frac{1}{5}$; B. $\frac{1}{4}$; P. $\frac{1}{9}$.	Ap. 27. Leaf partly unrolled. L. $\frac{2}{5}$; B. $\frac{2}{7}$.	Ap. 30. Expanded leaves. L. $\frac{5}{12}$; B. $\frac{2}{5}$; P. $\frac{1}{6}$.	May 6. L. $\frac{3}{5}$; B. $\frac{3}{5}$; P. $\frac{3}{5}$.
Rhododendron sinense.	Ap. 26. Yellowish, with inrolled margins. L. $\frac{1}{4}$; B. $\frac{1}{4}$.	....	Ap 30. Partly expanded. L. $\frac{4}{9}$; B. $\frac{2}{5}$.	May 6. Quite expanded. L. $\frac{3}{5}$; B. $\frac{2}{5}$.
Juglans nigra	Ap. 26. L. $\frac{1}{11}$. Leaflets, L. $\frac{1}{5}$; B. $\frac{1}{7}$.	Ap. 30. L. $\frac{1}{12}$. Leaflets, L. $\frac{1}{6}$; B. $\frac{1}{5}$.	May 6. L. $\frac{1}{5}$. Leaflets, L. $\frac{1}{4}$; B. $\frac{1}{3}$.	May 11. L. $\frac{1}{5}$. Leaflets, L. $\frac{4}{11}$; B. $\frac{5}{9}$.
Liquidambar stryraciflua.	Ap. 26. Leaves folded. L. $\frac{1}{5}$.	May 3. Partly expanded. L. $\frac{2}{11}$; B. $\frac{1}{9}$; P. $\frac{2}{7}$.	May 9. Fully expanded. L. $\frac{1}{4}$; B. $\frac{1}{4}$; P. $\frac{1}{2}$.	May 15. L. $\frac{2}{5}$; B. $\frac{3}{8}$; P. $\frac{4}{7}$.
Rhamnus grandifolia.	Ap. 26. Leaves partly expanded. L. $\frac{1}{5}$; B. $\frac{1}{18}$; P. $\frac{1}{11}$.	Ap. 30. Lamina pleated and yellowish. L. $\frac{2}{11}$; B. $\frac{2}{11}$; P. $\frac{1}{5}$.	....	May 6. L. $\frac{3}{11}$; B. $\frac{3}{11}$; P. $\frac{1}{5}$.
Fagus sylvatica v. *atropurpurea.*	Ap. 26. Fully expanded. L. $\frac{3}{14}$; B. $\frac{2}{5}$; P. $\frac{3}{10}$.	Ap. 30. L. $\frac{1}{2}$; B. $\frac{5}{9}$; P. $\frac{4}{5}$.	....	May 6. L. $\frac{2}{5}$; B. $\frac{2}{5}$; P. $\frac{1}{4}$.
Pyrus nivalis	Ap. 27. Buds partly opened. L. $\frac{1}{4}$.	May 3. Leaves expanded. L. $\frac{1}{3}$; B. $\frac{1}{4}$; P. $\frac{1}{5}$.	May 3. Fully expanded. L. $\frac{1}{4}$; B. $\frac{1}{2}$; P. $\frac{1}{5}$.	May 9. L. $\frac{3}{4}$; B. $\frac{7}{10}$; P. $\frac{3}{5}$.
Cornus candidissima...	Ap. 27. Buds just opened. L. $\frac{1}{5}$; B. $\frac{1}{7}$; P. $\frac{1}{3}$.	Ap. 30. L. $\frac{3}{11}$; B. $\frac{1}{4}$; P. $\frac{1}{5}$.	....	May 6. L. $\frac{1}{2}$; B. $\frac{1}{2}$; P. $\frac{1}{2}$.
Æsculus flava	Ap. 20. Buds fully opened. P. $\frac{1}{6}$. Leaflet, L. $\frac{1}{4}$; B. $\frac{1}{5}$.	Ap. 25. P. $\frac{1}{5}$. Leaflet. L. $\frac{1}{3}$; B. $\frac{1}{4}$.	....	Ap. 29. P. $\frac{1}{2}$. Leaflet, L. $\frac{1}{2}$; B. $\frac{1}{3}$.

largest and most fully-developed leaves. It is the age of the young leaf which is of primary importance with regard to its assimilatory powers, and the size of the developing leaf is the readiest, though not always the most accurate, indication of its age. Thus many actively assimilating early developed adult leaves are of smaller size than developing leaves which have not yet commenced to assimilate may be. If, however, at any given date it is always the largest and most fully developed leaves which are examined, this error is largely obviated.

From the table (p. 453–4) it appears that when the foliage is developing in spring, it is only when the leaves have reached a certain size and condition of development, which varies very much in different plants, that any power of assimilation can be detected. If branches are cut towards the end of winter and brought into a warm room with their lower ends in water, the buds in *Syringa* and *Salix* soon open and expand, though in other cases a long latent period intervenes.

	After 2 weeks. No Assimilation.	After 3 weeks. Weak Assimilation.	After 4 weeks. Fairly active Assimilation.
Syringa vulgaris ...	Buds opened. L. 1/6; B. 1/7; P. 1/4.	Chlorophyll grains quite green and fairly large. L. 1/3; B. 1/5; P. 1/4.	L. 1/3; B. 5/14; P. 1/3 to L. 2/5; B. 3/14.
Salix daphnoides ...	Chlorophyll grains small and yellowish. L. 1/6; B. 1/7.	Quite green. L. 1/4; B. 1/4.	L. 4/5; B. 6/7.

Comparison with the results in the previous table shows that under these conditions the power of assimilation takes longer to develop, but becomes active whilst the leaves are still relatively small. This is due to the abnormal conditions, and to the fact that the leaves on a cut branch rarely attain their full normal size.

In the young developing leaves of adult plants, perennials, annuals, mosses, &c., the results obtained are very similar to those already given.

	No evolution of Oxygen.	Weak but distinct Assimilation.	Moderately to fairly active Assimilation.	Assimilation quite active.
Oxalis Acetosella. Leaves developing on last year's rhizomes.	Pale yellowish green. Chlorophyll grains less than $\frac{1}{6}$ normal size. P. $\frac{1}{11}$. Leaflets, L. $\frac{1}{13}$; B. $\frac{1}{10}$.	As before, but chlorophyll grains $\frac{1}{3}$ to $\frac{1}{4}$ normal size. P. $\frac{1}{7}$. Leaflets, L. $\frac{1}{8}$; B. $\frac{1}{8}$.	Leaflets still folded and yellowish green. Chlorophyll grains $\frac{1}{2}$ to $\frac{1}{3}$; P. $\frac{3}{11}$. Leaflets, L. $\frac{1}{5}$; B. $\frac{1}{5}$.	Leaflets partly expanded and quite green. Chlorophyll grains $\frac{2}{3}$ to $\frac{1}{1}$. P. $\frac{3}{7}$. Leaflets, L. $\frac{1}{3}$; B. $\frac{1}{3}$.
Phaseolus vulgaris.	Yellowish green. Folded leaflets, L. $\frac{1}{8}$; B. $\frac{1}{4}$. Partially expanded leaflets, L. $\frac{2}{15}$; B. $\frac{1}{10}$.	Leaflets expanded and faintly yellowish. Chlorophyll grains small, but abundant and green. L. $\frac{1}{5}$; B. $\frac{1}{6}$.	Quite green *. L. $\frac{1}{4}$; B. $\frac{1}{5}$ (largest terminal leaflet).	Leaflets. L. $\frac{4}{9}$; B. $\frac{3}{7}$.

* At this stage in the development of the leaf its green colour is darkest. This is owing to the greater transparency of the young leaf, and not to any real greater intensity of coloration. The adult leaf, owing to the development of air-spaces in the mesophyll, becomes less transparent and of a lighter green tint.

Marchantia polymorpha.—Gemmæ, average adult diameter (D.) 1 mm. D. $\frac{3}{4}$. Quite active evolution of oxygen. D. $\frac{3}{10}$. Chlorophyll grains very small, but gemmæ green; distinct but much weaker assimilation. D. $\frac{2}{10}$ (100–200 cells). Chlorophyll grains extremely small. Margin almost colourless, centre yellowish green, and here just perceptible trace of evolution of oxygen. D. $\frac{1}{10}$. Central part distinctly greenish, but no evolution of oxygen.

Bryum cæspititium.—Length of leaf $\frac{3}{4}$ adult size. Chlorophyll grains about $\frac{1}{2}$ normal size and slightly yellowish, but assimilation quite active. L. $\frac{1}{20}$. Chlorophyll grains smaller and smaller from apex to base of leaf. Apical $\frac{1}{3}$ fairly active assimilation, middle $\frac{1}{3}$ weak, basal $\frac{1}{3}$ none. L. 1/[illegible]. Weak but distinct evolution of oxygen in apical $\frac{1}{4}$ of leaf only. L. $\frac{3}{8}$. No evolution of oxygen. Chlorophyll grains distinct and yellowish green in apical portion of leaf, but in basal part almost colourless.

Dicranum scoparium.—L. $\frac{1}{2}$. Quite active assimilation. L. $\frac{1}{3}$. Fairly active assimilation; basal part, chlorophyll grains smaller and weak assimilation. L. $\frac{3}{12}$. Protoplasm reticulate and transparent. Apical half, chlorophyll grains nearly normal size, moderately active assimilation; basal half, chlorophyll grains much smaller, assimilation quite weak. L. $\frac{1}{6}$. Apical portion, chlorophyll grains fairly large and green, very faint assimilation; basal half, chlorophyll grains smaller and smaller, at extreme base almost colourless, no evolution of oxygen. L. $\frac{1}{12}$. No evolution of oxygen. Chlorophyll grains in apical portion yellowish green, and, though small, larger than in base of leaf, L. $\frac{3}{14}$, where a weak assimilation is shown.

Catharinea undulata.—L. $\frac{1}{4}$. Apical $\frac{2}{3}$, chlorophyll grains $\frac{3}{4}$ to nearly full size, and quite active evolution of oxygen. Basal $\frac{1}{3}$, chlorophyll grains about $\frac{1}{6}$ normal size, and weak evolution of oxygen *. L. $\frac{1}{6}$. Apical portion, very weak evolution of oxygen, and chlorophyll grains $\frac{1}{2}$ to $\frac{1}{3}$ normal size. L. $\frac{3}{20}$. Chlorophyll grains abundant, green, and from $\frac{1}{3}$ to $\frac{1}{4}$ normal size in apical $\frac{2}{3}$ of leaf, but no evolution of oxygen, though the chlorophyll grains twice as large as, and in relation to the protoplasm in greater amount than, in the base of the leaf, L. $\frac{1}{4}$.

A careful study of the above results enforces the conclusion that, although the presence of a certain amount of chlorophyll is necessary before any evolution of oxygen can take place, nevertheless, in determining the development of the power of assimilation and the stage at which an evolution of oxygen is possible, equally important factors, of probably plasmatic origin, also enter into play. The leaves of Phanerogams and Mosses and the gemmæ of *Marchantia* are parasitic upon their parent plants for only a relatively short period at the commencement of their existence; for so soon as they show any evolution of oxygen, and this takes place at a comparatively early stage of their life-history, the power of assimilation is greater than that of respiration, and though at first, when the power of assimilation is still very weak, the substance gained during the day may be counterbalanced or more than counterbalanced by that lost by respiration during the night, very soon the amount gained by assimilation far surpasses that lost by respiration, and the leaf, instead of drawing supplies from the parent plant, sends supplies to it.

With moss-leaves it is especially noticeable that in the apical portion of the young leaf, which is more exposed to light and to contact with air, the chlorophyll grains increase more rapidly in size and the power of assimilation is sooner developed than in the more shaded basal portion of the leaf. The same

* In full-grown leaves of *Catharinea* the chlorophyll grains at the base of the leaf are much smaller ($\frac{1}{2}$ to $\frac{1}{3}$ and from $\frac{1}{4}$ to $\frac{1}{6}$ in relation to the size of the cell) than those in the rest of the leaf; the evolution of oxygen is correspondingly weaker, and is in some cases almost imperceptible. The cells at the base of the leaf seem to have, owing to their less exposed position and to their forming the channel of communication between the leaf and the stem, as much a conductory as an assimilatory function, and are especially liable to have their assimilatory powers still further diminished by an over accumulation of carbohydrates.

phenomenon may, however, also be shown by the leaves of certain Phanerogams.

Betula lenta.—Exposed but folded leaves. L. $\frac{1}{8}$, B. $\frac{1}{10}$. Green marginal leaf-teeth contain fairly large and green chlorophyll grains and show a weak evolution of O; whereas the central part of the leaf is red owing to the presence of a red sap in the epidermal cells which has disappeared from the more exposed epidermal cells of the leaf-teeth, shows no evolution of O., and the chlorophyll bodies are yellowish-green and from $\frac{1}{2}$ to $\frac{1}{3}$ the size of those in the mesophyll of the leaf-teeth. With leaves, L. $\frac{1}{5}$, B. $\frac{1}{8}$, in which the lamina is still pleated, the same relative differences in the size of the chlorophyll grains of the two parts are still shown, and whilst the body of the lamina shows only a very weak evolution of O, from the leaf-teeth this is moderatively active. With fully expanded leaves, L. $\frac{1}{3}$. B. $\frac{1}{4}$, in which the red colour is present only in the epidermal cells over the veins, the difference between the chlorophyll grains is no longer perceptible, and all parts of the leaf show a quite active power of assimilation.

Corylus Avellana.—Leaves, L. $\frac{1}{13}$, B. $\frac{1}{19}$, folded, hairy, and yellowish green. No evolution of O. Tip of leaf greener and very weak evolution of O. L. $\frac{1}{9}$, B. $\frac{1}{13}$; still folded and yellowish green. Tips of the teeth at the ends of the main veins with larger and greener chlorophyll grains and a moderately active evolution of O. Central part, chlorophyll grains smaller and more yellowish; evolution of O absent or barely perceptible, but in parts (over the veins and near the margin) a weak but distinct evolution of O. L. $\frac{1}{4}$, B. $\frac{1}{4}$, P. $\frac{1}{3}$. Leaf expanded. Teeth green, and show active evolution of O. Rest of leaf still slightly yellowish, and chlorophyll grains small and somewhat pale; moderately active evolution of O, which is in part weak. L. $\frac{3}{4}$, B. $\frac{1}{3}$, P. $\frac{2}{3}$. Chlorophyll grains equally large and green, and quite active assimilation in all parts.

In *Betula lenta* there is a very close correspondence between the commencement of assimilation and the disappearance of the protective red dye. In each part of the leaf, as the chlorophyll grains become adult and commence to assimilate, the red dye fades and disappears from the sap of the epidermal cells. In *Corylus*, assimilation appears sooner over the veins than in the rest of the lamina, because these parts are, in the folded condition of the leaf with the ventral surface outwards, more exposed to light and to contact with air than the depressed parts, covered thickly by hairs, lying between the ribs.

It does not necessarily follow that all power of assimilation is absent because no power of evolving oxygen is shown under optimal illumination, for it is always possible that a slight power of assimilation may be present, but is overpowered and masked by the active respiration of the young leaf. To determine whether or not this formed a serious source of error, comparative determinations were made of the amounts of CO_2 given off in

light and in darkness at different stages of their development by certain of the leaves previously examined. The CO_2 is absorbed by potash, and the decrease in the volume of the receiver gives the amount of CO_2 evolved, assuming that $\frac{CO_2}{O_2} = \frac{1}{1}$ is the respiratory quotient.

Corylus Avellana.—Temperature 25° C. 5 grammes in A, B, and C.

A. [Young apices, stipules removed.] Largest leaf, L. $\frac{1}{13}$, evolved of CO_2 in $3\frac{1}{2}$ hours in bright light 13·1 c.c., in darkness 13·9 c.c.

B. Leaves, L. $\frac{1}{9}$, B. $\frac{1}{13}$, evolved of CO_2 in $3\frac{1}{2}$ hours in bright light 6·1 c.c., in darkness 12·7 c.c.

C. Leaves, L. $\frac{1}{4}$, B. $\frac{1}{4}$, evolved of CO_2 in $3\frac{1}{2}$ hours in bright light 0·2 c.c., in darkness 8·1 c.c.

Phaseolus vulgaris.

D. 20 leaves, L. $\frac{1}{8}$, leaflets L. $\frac{2}{15}$, B. $\frac{1}{10}$, and partly expanded, evolved of CO_2 in 3 hours in bright light 1·9 c.c., in darkness 2 c.c.

E. 10 leaves, L. $\frac{3}{14}$, leaflets L. $\frac{1}{5}$, B. $\frac{1}{6}$, fully expanded, evolved of CO_2 in 3 hours in bright light 0·3 c.c., in darkness 2·5 c.c.

In C and E, although assimilation is stronger than respiration, a small quantity of CO_2 is given off on exposure to light. This is due to the escape and absorption of traces of respiratory CO_2, which when once absorbed are no longer available for assimilation, and the same phenomenon is shown by actively assimilating leaves when exposed to bright light. In A, C, D, and E the results coincide with those obtained by the Bacterium method; but in B respiration is apparently twice as active as assimilation, although by the Bacterium method a moderately active evolution of oxygen, which is in parts weak, is shown. This is because the leaves are at this stage folded and quite hairy, and are hence under less favourable conditions for assimilating and evolving oxygen than when examined in the form of sections under optimal illumination by the Bacterium method. Although, theoretically, gas analytical methods should, since they permit the error due to respiration to be allowed for, which is impossible by the Bacterium method, form a more certain test for the presence or absence of the power of assimilation than the latter, as a matter of practice, the Bacterium method is, largely owing to its microscopical and more specialized application, a much more delicate and certain detective agency.

Conclusions.

By the operation of a variety of agencies a condition of assimilatory arrest or inhibition may be induced in living chlorophyllaceous cells and tissues. These are: dry heat, moist heat, cold, desiccation, partial asphyxiation, etherization, treatment with acids, alkalies, and antipyrin, accumulation of the carbohydrate products of assimilation, immersal in very strong plasmolytic solutions, and prolonged insolation.

The inability to assimilate is, if the cell remain living, only temporary, being followed sooner or later by a more or less complete recovery of the power of assimilation.

During the whole time in which the power of assimilation is absent, the cell continues to respire. By the direct effect of each particular agency, the respiratory activity may in some cases be but little affected (etherization, over-accumulation of carbohydrates), in one case is increased (moist heat), but in most is diminished (cold, desiccation, immersal in strong plasmolytic solutions). The question, whether or not an after-effect may also be produced on respiration, is unable sensibly to affect the results obtained as regards assimilation. If the inhibition of assimilation experimentally produced be permanent the cell finally dies and ceases to respire.

In the great majority of cases no visible change in the chlorophyll or the chlorophyll grain is associated with the stoppage of assimilation. In such cases the assimilatory arrest probably originates in the plasmatic stroma of the chlorophyll corpuscle, and may be due to some breakage in the necessary vital connection between the assimilatory pigment and the assimilatory plasma.

Most of the above inhibitory agencies operate by checking or arresting the initial stages or primary processes of assimilation (decomposition of CO_2 and formation of carbohydrate); but since the accumulation of carbohydrate affects assimilation, any cause interfering with the rapidity of its removal from the assimilatory cells may also finally affect their power of assimilation.

Hence in the plant, as a whole, assimilation may be influenced by causes operating upon the general cell protoplasm and affecting the later stages in the process of assimilation (absorption, elaboration, and transformation of the assimilated carbohydrates), either of the assimilatory cell itself or of the cells which are dependent upon it for their supply of carbohydrate

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The last Meeting of the Session 1895–96 was held on June 18th last. Notice of the Meetings for the ensuing Session will be given in due course.

OCTOBER 31. *Price 4s.*

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7th May, 1896.

food-material, or by a closure of the channels through which these carbohydrates are removed.

Cells in which the green colour of the chlorophyll grains is quite masked by the presence of a brown or reddish-brown pigment may show a distinct power of assimilation. If the reduction of the chlorophyll be complete, assimilation ceases.

In certain cases isolated chlorophyll bodies may continue to assimilate for a short time after removal from the cell to which they belong.

A developing leaf in which the chlorophyll grains are being formed "*ab initio*" by protoplasmic differentiation lacks at first the power of assimilation. The commencement of assimilation is determined mainly by the development of the chlorophyll pigment, but is also largely influenced by other indeterminate factors, probably plasmatic in origin.

Postscript.—The above work was carried out in the Botanical Laboratory of the University of Leipzig during the years 1894 and 1895, under the direction of Professor Pfeffer, to whom my sincere and cordial thanks are due for his able and kindly assistance as well as for his searching but friendly criticism of the facts thereby brought to light.

Leipzig, April 1896.

Redescriptions of Berkeley's Types of Fungi. By GEORGE MASSEE, F.L.S., Principal Assistant (Cryptogams), Royal Herbarium, Kew.

[Read 16th April, 1896.]

(PLATES XVI.–XVIII.)

THE magnificent mycological herbarium of the Rev. M. J. Berkeley, M.A., F.R.S., presented to Kew in 1879, illustrates the numerous mycological publications by the author, dating from the appearance of the volume on Fungi in Smith's 'English Flora' (1836) to "Notices of Fungi collected in Zanzibar" (1885). The collection contains just over 11,000 species, of which 4866 are types described by Berkeley, either alone or in union with other authors. Many of the species were established half a century ago, consequently the diagnoses are brief, the characters comparative rather than positive, dealing almost entirely with superficial features, and hence are not sufficiently exact to secure identification of the species intended at the present day, when microscopic characters are considered of primary importance.

The object of the present contribution is to furnish full descriptions, with figures, of Berkeley's types, drawn up in every instance from the actual specimens used by the author in the first instance. The name originally given by Berkeley is in every case retained; the synonymy will indicate what changes have been introduced by other authors.

HELVELLA PUSILLA, *Berk. & Curt. in Proc. Amer. Acad.* vol. iv. (1860) p. 127; *Cooke, Mycogr.* p. 94, fig. 170; *Sacc. Syll.* viii. n. 80.

There is no specimen of the present species at Kew, and for that reason it would not have been alluded to here had not Cooke figured it in his 'Mycographia' with the assuring remark, "figured from drawings communicated by the Rev. M. J. Berkeley." On investigating this matter, it proved that Berkeley's drawings consisted of a pencil sketch of the smallest figure in Cooke's illustration, marked "n. s.," and two spores, marked "$\frac{1}{1000}$," with the following, "*Helvella pusilla*, B. & C., Behring's Straits. U.S.E.E. Stem whitish, hollow." The second

figure in Cooke's illustration is a copy of Berkeley's figure enlarged three times, and the third figure is an imaginary section of the same; the ascus with its 8 uniseriate spores is also imaginary. The original diagnosis given by Berkeley and Curtis is too brief to be of service, and from every point of view—unless specimens exist in the United States—the name should be allowed to drop.

HELVELLA GUEPINOIDES, *Berk. & Cooke in herb.*, *Cooke, Mycogr.* p. 198, fig. 337 (1878); *Phil. Brit. Disc.* p. 15; *Gillet, Disc. France*, p. 12, cum icon.; *Sacc. Syll.* viii. n. 65; *Massee, Fungus-Flora*, vol. iv. p. 462. (Pl. XVI. fig. 2.)

Pileus nearly entire, drooping on opposite sides and deeply depressed at the centre, the margin usually slightly wavy, quite free from the sides of the stem; substance rather thin, almost even, ochraceous, paler, even, and almost glabrous underneath, 2–4 cm. across; stem hollow from the first, 4–8 cm. high, up to 1 cm. thick, nearly equal throughout, even or with a tendency to become lacunose, whitish or with a more or less decided ochraceous tinge; asci cylindrical, apex somewhat truncate; spores 8, obliquely 1-seriate, smooth, continuous, hyaline, elliptical, ends obtuse, $18–20 \times 10–11\ \mu$; paraphyses septate, tips clavate.

On the ground, the type collected by the Rev. M. J. Berkeley at Coed Coch, near Bangor, Wales; also met with in France.

GYROMITRA TASMANICA, *Berk. & Cooke, Mycogr.* p. 193, fig. 331 (1878); *Sacc. Syll.* viii. n. 40. (Pl. XVI. fig. 1.)

Pileus drooping, margin more or less lobed, somewhat umbilicate or depressed at the centre, glabrous, rather fleshy, upper surface ornamented with slightly raised, anastomosing veins, bay-brown, under surface paler, entirely free and distant from the sides of the stem, 5–6 cm. across, 4 cm. deep; stem hollow, slightly thickened at the base, whitish, smooth, somewhat channelled longitudinally, 7–8 cm. long, 1 cm. or more thick at the apex; asci cylindrical, apex rather truncate; spores 8, obliquely 1-seriate, hyaline, smooth, continuous, elliptical, ends obtuse, averaging $25 \times 12\ \mu$; paraphyses rather stout, clavate and brown at the tip, septate.

Helvella tasmanica, Berk. in herb.

On the ground. Tasmania (*Archer*).

Type in Herb. Kew examined.

The present species agrees better with *Helvella* than *Gyromitra*. The pileus is more or less saddle-shaped, drooping, and quite free from the sides of the stem. The ribs on the hymenial surface are slight, and are indicated in many species included in *Helvella* by common consent.

Mitrula vinosa, *Berk. in Hook. f. Fl. Tasm.* ii. p. 273 (1860); *Cooke, Mycogr.* p. 104, fig. 181; *Sacc. Syll.* viii. n. 118. (Pl. XVI. fig. 3.)

Clustered or gregarious; entire fungus dingy vinous-purple, slender, straight or flexuous, 2–3·5 cm. high; club cylindrical, entire, even, obtuse, about equal in length to the stem, from which it is clearly differentiated, 1·5–2·5 mm. thick; stem slender, equal, glabrous, or sometimes apparently very minutely clothed with reddish down, especially near the base, rooting; asci narrowly cylindric-clavate, apex rounded, $60 \times 7\ \mu$; spores 8, irregularly 2-seriate, continuous, hyaline, smooth, straight or slightly curved, linear-elliptical, $9–12 \times 1·5–2\ \mu$; paraphyses slender, almost cylindrical.

On rotten wood. Tasmania (*Archer*).

Leotia elegans, *Berk. in Hook. Lond. Journ. Bot.* vol. v. (1846) p. 6.

Stem slender, straight, erect, even, glabrous, 5–7 cm. long, 2–3 mm. thick, equal; head clavate, 3–5 mm. long, slightly thicker than the stem, sometimes bifid; whole plant dull orange-brown (when dry); asci cylindric-clavate, apex rounded, 8-spored; spores irregularly 2-seriate, hyaline, smooth, continuous, narrowly fusiform, ends acute, $7–8 \times 1·5\ \mu$; paraphyses filiform, not thickened at the apex, hyaline, rather closely septate, about $2\ \mu$ thick.

Mitrula elegans, Berk. in Grevillea, vol. iii. (1875) p. 149; Syn. Helv. Pileat., Cooke, in Hedwigia, 1875, p. 7; Sacc. Syll. viii. n. 119.

On the ground among moss. United States (*Greene*, n. 66).

A peculiar species, remarkable for the long, straight, slender stem and small head, which seem to suggest the idea of having been drawn up by growing among tall moss, &c.; however, it can scarcely be considered abnormal, as there are eight perfect specimens in the Kew collection, all having been collected at the same time and place; but where that place is, beyond being in the United States, is unknown.

VIBRISSEA MICROSCOPICA, *Berk. & Broome in Ann. & Mag. Nat. Hist.* ser. IV. vol. xvii. (1876) p. 142 (n. 1618, Berk. & Broome); *Phillips, in Trans. Linn. Soc.* ser. II. *Bot.*, vol. ii. p. 7, tab. 1. figs. 17–24; *Phillips, Brit. Disc.* p. 319; *Sacc. Syll.* viii. n. 175; *Massee, Brit. Fungus-Flora*, vol. iv. p. 489.

Very minute, shortly stipitate, at first pyriform, then expanding and becoming concave or almost plane, grey, about ¼ mm. high and broad; excipulum pseudoparenchymatous, the cells running out into parallel, septate, olive-coloured hyphæ at the surface and margin; asci narrowly clavate, apex narrowed, blue with iodine, pedicel long and slender, 8-spored, about $80 \times 5\text{–}6\ \mu$; spores arranged in a parallel fascicle, hyaline, continuous, often slightly curved, needle-shaped, $50\text{–}60 \times 2\ \mu$; paraphyses very slender, numerous, tips not thickened.

On damp fir-wood. Rannoch, N.B. (*Dr. Buchanan White*).

Scarcely visible without a lens. Stem very short, black; head grey, leaving a cup-shaped depression when completely washed off; sporidia ejected, filiform. (*Berk. & Broome.*)

VIBRISSEA GUERNISACI, *Crouan, in Ann. Sc. Nat.* (*Bot.*), sér. IV. vol. vii. p. 176, tab. 4. figs. 24–26 (1857).

To this species the following must be referred as synonyms:—

Peziza leptospora, Berk. & Broome, in Ann. & Mag. Nat. Hist. ser. III. vol. xviii. (Aug. 1866), p. 126, t. 4. fig. 30 (n. 1166 of Berk. & Broome).

Vibrissea leptospora, Phillips, Brit. Disc. p. 320.

Gorgoniceps leptospora, Sacc. Syll. viii. n. 2086.

Vibrissea Guernisaci, Crouan, var. *leptospora*, Massee, Brit. Fungus-Flora, vol. iv. p. 488.

Patellaria Fergussoni, Berk. & Broome, in Ann. & Mag. Nat. Hist. ser. IV. vol. xv. (Jan. 1875), p. 39, t. 2. fig. 6 (n. 1490 of Berk. & Broome).

Vibrissea Fergussoni, Phillips, Brit. Disc. p. 318; Sacc. Syll. viii. n. 173.

In my Fungus-Flora, vol. iv. p. 488, *Peziza leptospora*, Berk. & Broome, and *Vibrissea Fergussoni*, Berk. & Broome, were shown to be identical, and were included under *Vibrissea Guernisaci*, Crouan, as var. *leptospora*. The varietal distinction was founded on differences in the paraphyses, but examination of authentic material of *V. Guernisaci* shows that this supposed difference is not permanent.

CORDIERITES CORALLOIDES, *Berk. & Curt. in Journ. Linn. Soc. (Bot.)* vol. x. p. 370 (1869); *Sacc. Syll.* viii. n. 3322. (Pl. XVIII. fig. 3.)

Erumpent; common stem breaking up at once into a variable number of rather slender, short (3–7 mm.), more or less crowded, minutely rough, dingy brown, simple or forked branchlets, each one usually bearing an ascophore at its apex; ascophore 2–3 mm. across, sometimes broader; margin at first incurved, then quite plane, brown; asci narrowly cylindrical; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, cylindric-ovate, ends obtuse, $5–6 \times 2{\cdot}5\,\mu$; paraphyses slender.

Parasitic on the stroma of decayed and old specimens of some species of *Hypoxylon*. Cuba (*Wright*, nn. 326, 504, 505).

A peculiar species, springing from the stroma of some *Hypoxylon* in all the specimens seen, and forming compact, coral-like tufts. May possibly prove to be a lichen.

CORDIERITES SPRUCEI, *Berk. Dec. Fung.* n. 619, *in Hook. Journ. Bot.* vol. viii. (1856) p. 280, t. 10. fig. 5; *Sacc. Syll.* viii. n. 3323. (Pl. XVIII. figs. 4, 5.)

Entire fungus dingy brownish-purple; stem up to 1 cm. high, simple or more frequently with 1–4 short branches, each bearing an ascophore at its apex; ascophores 2–5 mm. across, slightly oblique, funnel-shaped; externally, as well as the stem, minutely scabrid; excipulum formed of slender, thick-walled, septate, intertwined hyphæ which pass into a parenchymatous cortex, the cells running out in small groups to form the rough exterior; asci narrowly cylindrical, $50–60 \times 5\,\mu$; spores 8, 1-seriate, hyaline, continuous, smooth, elliptical, $5–6 \times 3\,\mu$; paraphyses cylindrical, septate, apex slightly narrowed, outline of wall slightly wavy towards the tips.

On rotten wood. Amazon Valley, Brazil (*Spruce*, n. 85).

Cartilaginous when dry. The hyphæ, asci, and paraphyses are all tinged with the purple colour of the fungus, which is soluble in a weak alkaline solution.

BULGARIA DECOLORANS, *Berk. & Curt. in Grevillea*, vol. iv. (1875) p. 6. (Pl. XVIII. figs. 23, 24.)

Gregarious; soft and tough when moist, rigid when dry; margin incurved and closed when young, then expanding until cup-shaped or pyriform, gradually narrowed below into a short, stout, stem-like base, glabrous externally and the stem more or

less wrinkled; white, becoming horn-colour with age and when dry, 2–4 mm. broad, up to 5 mm. high; entire substance of ascophore composed of very slender, interwoven hyphæ; asci cylindric-clavate, apex rounded and the wall very slightly thickened at this point, not at all blue with iodine, about 160 × 12 μ; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, narrowly elliptic-fusiform, often slightly curved, 28–33 × 5–6 μ; paraphyses very slender, not thickened at the tips.

Ombrophila decolorans, Sacc. Syll. viii. n. 2538.

On decayed oak-wood. Alabama (*Peters*, n. 5222).

Very remarkable in the genus *Ombrophila* on account of its white colour when fresh.

STICTIS (§ PROPOLIS) MACULARIS, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 371.

Gregarious, forming a small, whitish ring round each ascophore; elliptical, rarely subglobose, bordered by the torn and raised epidermis of the host-plant; disc pallid, up to 1 mm. long; asci narrowly clavate, tapering below into a slender pedicel, apex slightly narrowed, the minute apical plug alone blue with iodine, about 65 × 5–6 μ; spores hyaline, continuous, filiform, 45 × 1 μ, arranged in a parallel fascicle, which is slightly twisted on its axis; paraphyses filiform, not at all thickened upwards, often with short branchlets near the apex.

Nemacyclus macularis, Sacc. Syll. viii. n. 2879.

Exsicc. Fungi Cub. Wrightiani, n. 711.

On leaves of *Cyperus* sp. Cuba (*Wright*, n. 748).

The excipulum is obsolete, hence there is no proper margin, the sunk disc being at first covered and protected by the epidermis of the leaf on which it is growing, and which is finally ruptured, forming a spurious border.

MIDOTIS VERRUCULOSA, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 370; *Gard. Chron.* 1878, p. 769, fig. 134; *Sacc. Syll.* viii. n. 2258.

This species is identical with *Midotis heteromera*, Mont., Syll. Crypt. n. 642 (1856). Authentic specimen from Montagne examined.

Large concatenate cells are present in the excipulum, which suggest the gonidia of a lichen, but owing to age and poisoning for preservation the green colour, if ever present, has completely

gone. An examination of fresher material will be necessary to settle this point.

Cenangium Colensoi, *Berk. in Hook. f. Fl. Nov. Zeal.* ii. p. 201 (1855), *and in Handb. N. Zeal. Flora*, p. 629; *Sacc. Syll.* viii. n. 2329.

Ascophores gregarious or scattered, covered at first by the epidermis of the host-plant, then erumpent, oblong at first, and with the opposite sides of the excipulum incurved, then expanding and becoming orbicular and concave; substance thin, soft; 2–3 mm. across; disc pale watery-grey, often with a tinge of pink, externally and the margin glabrous, dark brown; hypothecium and excipulum hyaline, delicately parenchymatous, passing into large, dark brown cells at the cortex; asci cylindric-clavate, apex slightly narrowed, and not tinged blue with iodine; spores 8, irregularly 2-seriate, continuous, hyaline, smooth, elliptical, often slightly inæquilateral, 7×4 μ; paraphyses slender.

On dead leaves of *Phormium tenax*. New Zealand (*Colenso*, n. 4828).

The species is not a *Cenangium*, as considered by Berkeley; the soft, watery substance, glabrous exterior, and not being fasciculate or cæspitose in habit, are against this idea. On the other hand, the fungus is a typical *Pseudopeziza*, and should in future stand as *P. Colensoi*.

The elongated form of the fungus when young is caused by growing between the parallel rigid vascular bundles of the host-plant; when it first bursts through the epidermis, it opens by a long, narrow slit, as in *Hysterium*, but gradually expands and becomes circular and widely open.

Patellaria proxima, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. III. vol. vii. (1861) p. 450, tab. 16. fig. 18; *Massee, Fungus-Flora*, vol. iv. p. 101. (Pl. XVIII. figs. 13, 14.)

Gregarious, sessile, and semi-immersed in the matrix; plane, then slightly convex; black, often with a tinge of olive or brown when moist; $\frac{1}{2}$–$\frac{3}{4}$ mm. across; hypothecium dense, brownish, composed of indistinct, more or less parallel, dingy olive hyphæ; asci clavate, gradually narrowing from the apex into a slender pedicel, apex rounded, wall thin, not at all tinged blue with iodine, about $140 \times 14\,\mu$; spores 8, obliquely 1-seriate

below, irregularly 2-seriate upwards, hyaline, smooth, narrowly elliptical, straight or slightly curved, 3-septate, rarely becoming 5-septate, 18–25 × 5 μ; paraphyses very slender, numerous, more or less agglutinated together at the slightly thickened, coloured tips.

Lecanidion proximum, Sacc. Syll. viii. n. 3261.

On old weathered oak-wood. England (*Berkeley* & *Leighton*).

Agreeing closely with *Patellaria fusco-atrum* in the spores, differing in the wall of the ascus not being at all thickened at the apex, and not blue with iodine, also in the immarginate ascophore being somewhat buried between the fibres of the weathered wood on which it grows. *Odontotrema longius*, Nyl., is identical with the present species.

Psilopezia flavida, *Berk. & Curt.*, *N. Amer. Fung.*, *in Grevillea*, vol. iv. (1875) p. 1; *Sacc. Syll.* viii. n. 612. (Pl. XVI. fig. 10.)

Crowded and sometimes confluent; often orbicular when solitary, plane, sessile, rather fleshy, margin free and somewhat raised when full grown, 3–6 mm. across, glabrous; disc yellow; ascophore parenchymatous, cortical cells polygonal, large; asci narrowly cylindrical, apex obtuse, not becoming blue with iodine, about 120 × 7–8 μ; spores 8, vertically 1-seriate, hyaline, continuous, smooth, 2-guttulate, elliptic-oblong, ends obtuse, 12–14 × 7 μ; paraphyses very slender, not thickened at the tip, not longer than the asci.

On rotten wood of *Quercus alba*. Alabama, U.S.A. (*Peters*, n. 5233).

Differing from the three remaining species placed by Berkeley in not being floccose underneath, and hence not having a downy margin; small spores; very slender, colourless paraphyses not longer than the asci; and in the margin being free and raised from the substratum. I should place the present species in the genus *Mollisia*.

Psilopezia nummularia, *Berk. in Lond. Journ. Bot.* vol. vi. (1847) p. 325. (Pl. XVI. fig. 13.)

Suborbicular, plane, sessile, rather fleshy, attached by the entire under surface, which is more or less downy or strigose, the hyphæ forming a pale fringe round the margin when the plant is in full growth; disc glabrous, purplish-brown or

blackish-green, 1–3 cm. diameter; ascophore parenchymatous, the cortical cells hexagonal, 28–36 μ diameter; asci cylindrical, apex rounded, blue with iodine, as are also the paraphyses when old, about 225×16–$17\ \mu$; spores 8, 1-seriate, hyaline, continuous, smooth, often 2-guttulate, broadly elliptical, ends obtuse, wall rather thick, 20–23×13–$14\ \mu$; paraphyses numerous, stout, becoming gradually thicker and brown upwards, tips 7–8 μ thick, septate, longer than the asci.

Psilopezia nummularis, Sacc. Syll. viii. n. 615.

Psilopezia myrothecioides, Berk. & Broome, Not. Brit. Fung., in Ann. & Mag. Nat. Hist. ser. IV. vol. xv. (1875) p. 39, t. 2. fig. 5; Sacc. Syll. viii. n. 617.

Rhizina myrothecioides, Massee, Brit. Fungus-Flora, vol. iv. p. 455.

Exsicc. Ellis, N. Amer. Fung. n. 568.

On damp, rotten wood. United States—Ohio (*Lea*, n. 243, with query, "Myrothecium?"); Pennsylvania (*Michener*, n. 3530); S. Carolina (*Ravenel*, n. 2959); New Jersey (*Ellis*) (called *Psilopezia myrothecioides*). Scotland (*Rev. J. Fergusson*).

When old the margin becomes bald, and sometimes becomes slightly raised from the substratum.

A careful comparison of the types of *P. nummularia* and *P. myrothecioides* shows that the two are identical in structure, differing only in the colour of the disc, consequently the last named must be reduced to a synonym of the first named. The plants appear to increase in size by constant extension of the margin, as in the genus *Corticium*. The genus *Psilopezia*, established by Berkeley (Lond. Journ. Bot. vol. vi. (1849) p. 325), resembles superficially the genus *Phillipsia*, but is distinguished by the parenchymatous structure of the ascophore, and the stout, clavate, brown paraphyses, which are longer than the asci. On the other hand, there is an absolute agreement between the present genus and *Rhizina*, unless we limit the last-named genus to *R. inflata*, Quél., which would then differ in the presence of continuous thick-walled brown tubes in the hymenium differing in structure from the paraphyses.

Rhizina spongiosa, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 364; *Sacc. Syll.* viii. n. 184. (Pl. XVII. fig. 33.)

Sessile, sometimes narrowed into a very short stem-like base,

thick and fleshy, becoming thin towards the incurved margin, somewhat gelatinous when moist, 2–5 cm. across; disc smooth, pale brown; externally and the margin densely clothed with sooty-brown, cylindrical, obtuse, wavy, septate hairs, 200–300 × 7–8 μ, more or less intermixed, and forming a felted mass; hypothecium and excipulum formed of contorted and interwoven, branched, hyaline hyphæ, about 3 μ diameter, and embedded in mucilage; these become thicker, brown, and more closely compacted to form the cortex, and run out into the external hairs; asci cylindrical, apex rounded and not blue with iodine, narrowed below into a long pedicel, 8-spored, wall thick; spores obliquely 1-seriate, continuous, wall thick, smooth, often guttulate, elliptical, ends narrowed, hyaline (then brown, but this colour may be the result of poisoning), 42–45 × 12–14 μ; paraphyses numerous, cylindrical, septate, apices thickened and brownish.

Rhizina Thwaitesii, Berk. & Broome, in Journ. Linn. Soc. (Bot.) vol. xiv. (1875) p. 102; Sacc. Syll. viii. n. 185.

Bulgaria trichophora, Massee, in Journ. Bot. vol. xxix. (1891) p. 2, pl. 300. figs. 7–10; Sacc. Syll. x. n. 4620.

Exsicc. Fung. Cubenses Wrightiani, n. 654.

Growing on branches and rotten wood. Cuba (*Wright*, nn. 383, 638, 646, 933); Ceylon (*Thwaites*); Madagascar (*Baron*).

The spores are perfectly smooth, but often containing granular contents, in the Ceylon form described by Berkeley as *Rhizina Thwaitesii*. I am still of the opinion that the present species is much more nearly allied to *Bulgaria* than to *Rhizina*.

RHIZINA ZONATA, *Berk. in Hook. Kew Journ. Bot.* vol. vi. (1854) p. 6; *Sacc. Syll.* viii. n. 186. (Pl. XVIII. fig. 10.)

Orbicular when young, but often becoming irregular with age; increasing in size by marginal growth, which appears to be arrested at times, thus producing concentric zones on the under surface; rather fleshy; disc smooth, dark brown, externally uniformly densely but minutely velvety, 2–4 cm. across; hypothecium, excipulum, and cortex uniform in structure, and composed of brown, rather thick-walled, intricately interwoven hyphæ, 5–7 μ thick, many of these hyphæ become straight and run up amongst the paraphyses and asci; asci cylindrical, apex blunt, 8-spored; spores obliquely 1-seriate, continuous, smooth, elliptic-fusiform, ends acute, often 2-guttulate, slightly tinged brown at maturity,

averaging 35 × 8–9 μ; paraphyses numerous, slender, cylindrical, hyaline throughout, rather closely septate.

Amongst pine-leaves. Darjeeling (*Dr. Hooker*).

Very closely allied to *Rhizina inflata*, Quélet; differing in the absence of rhizoids on the under surface of the ascophore, and the slender, cylindrical, hyaline paraphyses.

Phillipsia subpurpurea, *Berk. & Broome, in Trans. Linn. Soc.* ser. II. *Bot.* vol. ii. (1882) p. 69; *Sacc. Syll.* viii. n. 607. (Pl. XVI. fig. 9.)

Ascophore sessile, attached by a central point, thick and fleshy, margin irregularly lobed, edge not upturned; disc nodulose or wavy, reddish-purple, becoming tinged brown when dry; under surface variously wrinkled and contracted, pallid, margin more or less tinged with red, glabrous, 3–6 cm. broad; hypothecium of very densely interwoven hyphæ, as is also the cortex, excipulum lax, all the hyphæ hyaline and about 5–6 μ thick; asci cylindrical, apex rounded, and not becoming blue with iodine, wall thick, 8-spored, about 300 × 16 μ; spores 1-seriate, hyaline, continuous, smooth, elliptical, ends obtuse, often slightly inæquilateral, guttulate, 27–30 × 12–14 μ; paraphyses cylindrical, about 3 μ thick.

On rotten wood close to the ground. Brisbane (*Bailey*, n. 167).

The largest species of the genus *Phillipsia*. Thick and fleshy when fresh, much contracted when dry; flesh white.

The genus *Phillipsia*, Berk. in Journ. Linn. Soc. (Bot.) vol. xviii. (1881) p. 388, from examination of type specimens, should be emended as follows:—Ascophore sessile, fleshy, discoid, marginate, expanded from the first, glabrous; composed entirely of slender interwoven hyphæ, which are densely compacted in the hypothecium and cortex, very loosely interwoven in the median portion or excipulum; asci cylindrical, apex obtuse; spores 8, 1-seriate, continuous, hyaline, large, elliptical or elliptic-oblong; paraphyses present.

Growing on rotten wood or on the ground.

When dry the hymenium becomes cracked as in the genus *Corticium*, and often separates spontaneously from the cortical portion of the ascophore, owing to the very scanty network forming the excipulum.

The following species also show the above points of structure,

and should be placed in the genus *Phillipsia*:—*Phillipsia Venezuelæ*, Berk. & Curt.; *Peziza domingensis*, Berk.; *Peziza emarginata*, Berk. & Broome.

Phillipsia Venezuelæ, *Berk. & Curt. in herb.* (Pl. XVI. figs. 4, 5.)

Plane and discoid, with a very slightly upraised margin, everywhere glabrous; rather fleshy, sessile, but narrowed below to a very short point of attachment; disc orange, externally and the margin paler; hypothecium formed of very thin, densely interwoven, septate, hyaline hyphæ, central portion formed of a very lax weft, which becomes dense and interwoven again to form the cortex; asci cylindrical, wall thick, apex rounded, not coloured by iodine; spores 8, obliquely 1-seriate, hyaline, elliptic-fusiform, ends pointed, sometimes apiculate, wall thick, smooth, hyaline, continuous, usually 4-guttulate, $28–31 \times 12–14$ μ; paraphyses very slender, scarcely thickened upwards.

Peziza (§ *Cochleatæ*) *Venezuleæ*, Cooke, Mycogr. p. 120, fig. 206; Sacc. Syll. viii. n. 255.

On the ground. Venezuela.

Cooke's figures in 'Mycographia' are not correct; there is only one specimen in Berkeley's herbarium, which is discoid as described above. When dry the substance is thin, and the hymenium cracked as in many species of *Corticium*. The very few hyphæ forming the central portion of the excipulum (Pl. XVI. fig. 4 *d*) causes the hypothecium, *c*, along with the asci, *a*, and paraphyses, *b*, to separate readily from the cortical portion, *e*. The asci measure about 300×16 μ.

Under surface of ascophore with slender wrinkles radiating from the point of attachment in the dry specimen.

Helotium agaricicolum, *Berk. & Broome, Fungi of Ceylon*, n. 959, *in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 107; *Sacc. Syll.* viii. n. 1037. (Pl. XVII. figs. 26, 27.)

Gregarious; rather fleshy, pliant when moist, brown when dry, closed at first, soon becoming plane or with the extreme margin upturned, glabrous; gradually narrowed into a short stem-like base, every part dingy purple, 1·5–2·5 mm. across; hypothecium and excipulum consisting of slender, violet-tinged, intricately interwoven hyphæ, which appear to be imbedded in mucilage when moist; asci narrowly cylindrical, pedicel slender; spores 8, obliquely 1-seriate, elliptic-oblong, often

slightly oblique, ends obtuse, smooth, continuous, clear brown, translucent, 8–9 × 4 μ; paraphyses slender, almost cylindrical.

On decaying Agarics. Peradeniya, Ceylon (*Thwaites*, n. 13).

The present remarkable fungus evidently belongs to the Bulgarieæ, and to the genus *Bulgaria*, and will afterwards be known as *Bulgaria agaricicola*.

HELOTIUM AGLÆOSPORIUM, *Berk. & Curt. N. Amer. Fung* n. 752, *in Grevillea*, vol. iv. (1875) p. 1; *Sacc. Syll.* viii. n. 1018.

This species is in absolute agreement in every point with the following, of which it will stand as a synonym:—

Peziza pateræformis, Berk. in Hook. f. Flor. Tasm. vol. ii. p. 276 (1860).

Helotium pateræforme, Sacc. Syll. viii. n. 1028; Cooke, Austr. Fung. p. 264.

HELOTIUM MONTICOLUM, *Berk. N. Amer. Fung.* n. 751, *in Grevillea*, vol. iv. (1875) p. 1; *Sacc. Syll.* viii. n. 1011. (Pl. XVII. figs. 21, 22.)

Gregarious or crowded; closed at first, soon plane, finally slightly convex, sharply marginate, fleshy, narrowed below into a stout short base, glabrous, entirely dingy-orange or tawny when dry, 1–1·5 mm. across; hypothecium and excipulum parenchymatous; cortical cells polygonal, rather large; asci clavate, apex rather narrowed, not coloured blue with iodine, wall rather thick; spores 8, irregularly 2-seriate, hyaline, continuous, straight, elliptic-fusiform, ends narrowed, 12–14 × 5 μ; paraphyses numerous, slender, almost cylindrical.

On dead wood. Mountains of Upper Carolina (*Ravenel*, n. 4471. Given as n. 470 by Berkeley by mistake).

Closely allied to *Helotium citrinum*; distinguished by the different structure of the ascophore and the 2-seriate larger spores.

HELOTIUM RHYTIDODES, *Berk. & Curt. Cuban Fungi*, n. 700, *in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 369; *Sacc. Syll.* viii. n. 924. (Pl. XVII. figs. 12, 13, & 20.)

Gregarious or scattered; rather fleshy, sessile, rigid when dry, every part coloured alike, varying from yellow to reddish orange; closed and globose at first, then expanding, but the extreme margin usually more or less upturned, 2–4 mm. across, narrowed

below into a short stout stem-like base; hypothecium and excipulum formed of slender interwoven hyphæ; asci cylindrical, apex obtuse and not coloured blue by iodine, base short and narrowed; spores 8, obliquely 1-seriate, elliptic-oblong, ends obtuse, usually 2-guttulate, hyaline, smooth, continuous, 11–12 × 7 μ; paraphyses numerous, very slender, cylindrical, closely septate throughout their length.

Helotium crocinum, Berk. & Curt. Cuban Fungi, n. 701, in Journ. Linn. Soc. (Bot.) vol. x. (1869) p. 369; Sacc. Syll. viii. n. 909.

On dead twigs and bark. Cuba (*Wright*, nn. 373 & 374).

Remarkable in having the paraphyses closely septate throughout their length.

Helotium Laburni, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. IV. vol. xvii. (1876) p. 143; *Grevillea*, vol. v. p. 62; *Sacc. Syll.* viii. n. 1027; *Massee, Fungus-Flora*, vol. iv. p. 235; *Bresad. Fung. Trid.* p. 69, tab. 74. fig. 2.

Gregarious; sessile or shortly stipitate, closed at first, at length almost or quite plane, margin usually slightly incurved; disc whitish, ochraceous, or yellow, externally pale and minutely furfuraceous, up to 1 mm. broad and about the same high; hypothecium and excipulum formed of hyaline interwoven hyphæ which run parallel in the cortex and end in short slender parallel hyphæ at the margin; asci cylindrical, apex obtuse, pedicel narrowed; spores 8, irregularly 2-seriate or sometimes almost obliquely 1-seriate, hyaline, continuous, smooth, 3–4-guttulate, fusiform, ends rather pointed or the apex sometimes obtuse, 18-22 × 6–7 μ; paraphyses numerous, about 2 μ thick, hyaline, tips only slightly thickened.

Hymenoscypha Laburni, Phillips, Brit. Disc. p. 135.

On branches of laburnum (*Cytisus Laburnum*). Menmuir, N.B. (*Rev. M. Anderson*).

Usually on decorticated branches, the bark apparently thrown off by the fungus, as is the case with *Corticium comedens*. In some instances, however, the fungus grows on the bark itself, which then remains on the branch.

Superficially resembling *Helotium salicellum*, which, however, differs in the ultimately septate spores and in the margin of the ascophore not being furnished with a minute fringe of parallel hyphæ.

Helotium alutaceum, *Berk. & Broome, Fungi of Ceylon*, n. 956, *in Journ. Linn. Soc. (Bot.)* vol. xiv. (1875) p. 107; *Sacc. Syll.* viii. n. 1020. (Pl. XVII. fig. 24.)

Gregarious or often cæspitose and overlapping; sessile, closed at first, then expanding, the margin remaining erect, finally becoming plane and usually more or less wavy, the extreme margin usually remaining upturned; attached by a narrowed base, which, along with the margin, is at first covered with a delicate white tomentum, at length glabrous, rather fleshy, yellowish-ochre (when dry), 1·5–2 mm. across; hypothecium and excipulum formed of slender, densely interwoven hyphæ; asci cylindrical, apex rounded, not coloured blue with iodine; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, wall rather thick, elliptic-oblong, ends obtuse, 12–14 × 7 μ; paraphyses numerous, slender, very slightly thickened at the tips.

On weathered wood. Peradeniya, Ceylon (*Thwaites*, n. 65).

Helotium miserum, *Berk. & Curt. in Journ. Linn. Soc. (Bot.)* vol. x. p. 369 (1869); *Sacc. Syll.* viii. n. 877. (Pl. XVII. figs. 9–11.)

Gregarious or scattered; clavate, then urceolate, narrowed below into a short stem-like base, glabrous, whitish, pallid when dry, rather firm, 1·5–2 mm. high; cortex composed of very long narrow cells arranged in a parallel series running from base to margin; asci clavate, apex narrowed, thick-walled, no trace of blue, but the entire wall of the ascus becoming brown with iodine; spores 8, irregularly 2-seriate, smooth, hyaline, 4-guttulate, finally becoming 3-septate, narrowly clavate, apex thickest, 12–14 × 5 μ; paraphyses filiform.

On bark amongst moss. Cuba (*Wright*, n. 456).

On account of the 3-septate spores, the present species will stand as *Belonidium miserum*. Berkeley described the spores as "endochromate demum quadripartito," but on examining the type specimen I find many of the spores distinctly 3-septate.

Helotium lentum, *Berk. & Broome, Fung. Ceylon*, n. 961, *in Journ. Linn. Soc. (Bot.)* vol. xiv. (1875) p. 108; *Sacc. Syll.* viii. n. 930. (Pl. XVII. fig. 16.)

Scattered; stipitate, at first with the margin incurved, soon becoming quite plane, glabrous, externally more or less covered with radiating wrinkles originating from the apex of the stem, reddish-brown when dry, becoming paler and yellowish when moistened, 1·5–2 mm. across; hypothecium and excipulum formed

of slender hyphæ, which become arranged in a parallel series and run from base to margin in the cortex; stem about equal in length to diameter of ascophore, slender, glabrous, blackish; asci cylindrical, apex rounded and blue with iodine; spores 8, irregularly 2-seriate, narrowly cylindrical, ends obtuse, hyaline, smooth, continuous, straight, $6 \times 2\ \mu$; paraphyses slender, very slightly thickened upwards.

On dead leaves, moss capsules, &c. Ceylon (*Thwaites*, n. 104).

Allied to such species as *Helotium virgultorum* and *H. Calyculus*, but differing in the smaller spores and black stem.

HELOTIUM FASCICULARE, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 107. (Pl. XVII. figs. 7, 8.)

Fasciculate, numerous stems springing from a common base, a few peripheral specimens sometimes scattered; soft and subgelatinous when moist, rigid and horny when dry, entirely pallid, becoming pale amber during drying, glabrous; ascophore plane, then slightly convex, margin acute, 2–3 mm. across; stem almost equal or thickened upwards, rather stout, 2–3 mm. long; entire substance composed of very slender, densely interwoven hyphæ, the outer walls of which deliquesce and form a gelatinous hyaline mass, which becomes deep blue with iodine; asci cylindrical, apex obtuse, base narrowed, not at all coloured with iodine; spores 8, 1-seriate, smooth, hyaline, continuous, broadly elliptical, ends obtuse, $8\text{–}9 \times 6\text{–}7\ \mu$; paraphyses filiform, apex not incrassated, about $1\ \mu$ thick.

Pitya fascicularis, Sacc. Syll. viii. n. 851.

On bark. Peradeniya, Ceylon (*Thwaites*, n. 1133).

The present species belongs to the Bulgarieæ, and in a modern arrangement will stand as *Ombrophila fascicularis*. Remarkable for the hypothecium and excipulum becoming coloured deep blue on the application of a solution of iodine, whereas under the same treatment the asci remain uncoloured.

HELOTIUM RUFO-CORNEUM, *Berk. & Broome, Fungi of Ceylon, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 108; *Sacc. Syll.* viii. n. 961.

This species is in every respect identical with *Peziza crocata*, Mont.; as the published description of the last-named species is imperfect, a description is given, drawn up from a portion of the type gathering made by Leprieur in Guiana, which was sent to Berkeley by Montagne.

PEZIZA CROCATA, *Mont. Syll. Crypt.* n. 625, p. 186 (1856); *Mont. Cent.* ii. n. 19. (Pl. XVII. fig. 14.)

Gregarious or scattered; stipitate, at first globose and closed, finally almost or quite plane, slightly fleshy, glabrous, 1–3 mm. diameter, externally often radially rugulose, varying in colour from orange yellow to reddish; hypothecium and excipulum formed of slender interwoven hyphæ, which become arranged in a parallel series running from base to margin in the cortex; stem slender, 2–4 mm. long, equal or expanding at the apex, usually paler than the ascophore and at first covered near the base with very delicate evanescent down, frequently slightly curved; asci clavate, thick-walled, apex slightly narrowed, thick, tinged blue with iodine; spores 8, irregularly 2-seriate, narrowly cylindric-fusiform, ends pointed, continuous, hyaline, smooth, straight, $25–30 \times 3–6\ \mu$; paraphyses numerous, very slender, slightly thickened at the tips.

Phialea crocata, Sacc. Syll. viii. n. 1082.

Helotium rufo-corneum, Berk. & Broome, in Journ. Linn. Soc. (Bot.) vol. xiv. (1875) p. 108; Sacc. Syll. viii. n. 961.

On petioles of fallen leaves, Guiana (*Leprieur*); on dead wood, Ceylon (*Thwaites*, n. 282).

HELOTIUM MELLEUM, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. IV. vol. xv. (1875) p. 38; *Phillips, Brit. Disc.* p. 160; *Massee, Fungus-Flora*, vol. iv. p. 242. (Pl. XVII. fig. 19.)

Scattered or gregarious; stipitate, closed at first, soon becoming quite plane, but with the extreme margin usually slightly upturned, often wavy, pale honey-colour everywhere, 1–1·5 mm. across; hypothecium and excipulum parenchymatous; cortical cells polygonal or subquadrate, almost uniform in size throughout, $7–10\ \mu$ diameter; stem short, stout, glabrous; asci clavate, apex narrowed, pedicel long, slender; spores 8, irregularly 2-seriate, smooth, hyaline, narrowly fusiform, ends rather acute, very slightly bent or with a suggestion of becoming sigmoid, often multiguttulate, $21–32 \times 5–6\ \mu$; paraphyses hyaline, about $1{\cdot}5\ \mu$ thick, scarcely or often not at all thickened at the tips.

Helotium Fergussoni, Sacc. Syll. viii. n. 948.

On rotten wood. New Pitsligo, N.B. (*Rev. J. Fergusson*).

The present species was published in January 1875, and later in the same year Berkeley and Broome published a second quite distinct species from Ceylon as *Helotium melleum*. The name

of *H. melleum* has been retained by Saccardo (Syll. viii. n. 1002) for the Ceylon species; and the British species, notwithstanding priority of publication, has been changed to *Helotium Fergussoni*, Sacc. Syll. viii. n. 948. This mistake has been corrected in my 'Fungus-Flora,' vol. iv. p. 243.

HELOTIUM SUBLATERITIUM, *Berk. & Broome, Not. Brit. Fung.* n. 1488, *in Ann. & Mag. Nat. Hist.* ser. IV. vol. xv. (1875) p. 38; *Phillips, Brit. Disc.* p. 161; *Sacc. Syll.* viii. n. 933; *Massee, Fungus-Flora*, vol. iv. p. 253. (Pl. XVII. figs. 17, 18.)

Scattered or gregarious; stipitate, soon becoming quite plane, or the extreme margin upturned, glabrous, pale brick-red, under surface minutely radially wrinkled, 1–1·5 mm. across; stem short, widening upwards into the base of the ascophore, coloured, at first covered with delicate white down, becoming glabrous; hypothecium and excipulum formed of hyaline, thin, intricately interwoven hyphæ that run out into a small-celled parenchymatous cortex; asci elongated, narrowly clavate, apex slightly narrowed, pedicel long, slender; spores 8, irregularly 2-seriate above, 1-seriate below, smooth, hyaline, continuous, elliptic-fusiform, straight or very slightly bent, sometimes 2-guttulate, 24–26 × 5–6 μ; paraphyses slender, hyaline, tips scarcely thickened.

On dead stems of herbaceous plants. Glamis, N.B. (*Rev. J. Stevenson*).

Distinguished by the discoid, pale red hymenium, the minutely wrinkled under surface of the ascophore, and the large spores.

PEZIZA (§ HELVELLOIDEÆ) MICROSPORA, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 150; *Cooke, Mycogr.* p. 158, fig. 271.

Gregarious or crowded, and often irregular in form from pressure, narrowed to a point of attachment, but not stipitate, fleshy, fragile; disc orange-yellow, externally pallid and minutely pulverulent or pruinose, due to the outgrowth, in minute groups, of some of the cortical cells, up to 1 cm. across; hypothecium, excipulum, and cortex formed of thick irregularly swollen hyphæ, densely interwoven, hyaline; asci cylindrical, apex obtuse, not becoming blue with iodine, 100 × 5–6 μ; spores 8, obliquely 1-seriate, hyaline, continuous, smooth, elliptic-oblong, ends obtuse, 7–8 × 4 μ; paraphyses rather slender, tips not much thickened.

Humaria microspora, Sacc. Syll. viii. n. 510.

On damp rotten wood near the ground. Lower Carolina (*Ravenel*, nn. 2970 & 1031).

By a slip of the pen, Saccardo gives the spore measurements 18 μ long instead of 8 μ. The present species is allied to *Peziza flavo-tingens*, Berk. & Broome, in the structure of the ascophore and the pulverulent exterior.

Peziza (§ Discina) radiculosa, *Berk. & Broome, Fung. Ceylon*, n. 923, *in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 103; *Cooke, Mycogr.* p. 61, fig. 107. (Pl. XVI. fig. 12.)

Ascophore subglobose, then expanding until nearly plane, rather fleshy, entirely orange-colour; disc slightly concave, even, externally minutely downy, becoming bald with age, sending down a more or less fibrous, rooting, stem-like base, up to 1 cm. across; flesh yellow; hypothecium formed of densely interwoven thick-walled hyphæ 4 μ thick, these become abruptly thickened in the excipulum and cortex to 7–8 μ and densely interlaced; asci cylindrical, apex obtuse, not blue with iodine, 8-spored; spores continuous, hyaline, smooth, elliptical, obliquely 1-seriate in the ascus, $7 \times 3{\cdot}5$ μ; paraphyses filiform, tips not thickened.

Sarcoscypha radiculosa, Sacc. Syll. viii. n. 625.

On soil. Ceylon (*Thwaites*, n. 10).

The ascophores, when expanded, lie flat on the soil. A very distinct species, known by the small spores, structure of the ascophore, and rooting, stem-like base.

Peziza (§ Discina) sarmentorum, *Berk. & Broome in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 102; *Cooke, Mycogr.* fig. 267.

Scattered or gregarious; sessile, globose and closed at first, then gradually expanding until almost or quite plane, rather thin and somewhat gelatinous when moist, 4–16 mm. across; entirely pale tan-colour (when dry); hymenium slightly wrinkled or veined; externally minutely scurfy, due to the outgrowth of groups of the cortical cells; excipulum entirely parenchymatous, hypothecium brown; asci cylindrical, apex somewhat truncate, about 180×11 μ, becoming blue with iodine; spores 8, obliquely 1-seriate, elliptic-oblong, ends obtuse, continuous, even, hyaline, 1-2-guttulate, 18×9 μ; paraphyses rather stout, slightly thickened upwards, septate.

On twigs and petioles. Ceylon (*Thwaites*, n. 3).

Peziza (§ Discina) dochmia, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 364; *Cooke, Mycogr.* p. 128, fig. 221; *Sacc. Syll.* viii. n. 353.

Ascophore flabellate or broadly obovate, narrowed into a very short, flattened, stem-like point of attachment; substance rather thin, margin at first involute, then becoming almost plane, but the extreme edge nearly always permanently incurved; disc brown, even, becoming cracked when dry, externally pale, almost or quite glabrous, often more or less rugulose, about 2·5 cm. broad and long; hypothecium and excipulum formed of interwoven hyphæ, which in the last-named structure are combined to form an open spongy structure, becoming densely interwoven and tinged brown in the cortical portion; asci cylindrical, apex rounded and not blue with iodine; spores 8, obliquely 1-seriate, continuous, hyaline, often 2-guttulate, smooth, elliptical, slightly inæquilateral, 28–30 × 12–13 μ; paraphyses slender, slightly thickened and tinged brown at the tips.

Peziza (§ *Discina*) *hirneoloides*, Berk. & Curt. in Journ. Linn. Soc. (Bot.) vol. x. (1869) p. 365; Cooke, Mycogr. p. 127, fig. 220; Sacc. Syll. viii. n. 358,

Exsicc. Fungi Cub. Wrightiani, n. 661.

Growing on rotten wood and branches. Cuba (*Wright*, nn. 661, 662, 659, & 236); Africa, "Tropic of C., in dense jungle" (*Nelson*); Clarence River, Australia (*Beckler*, n. 6).

The type specimens prove the correctness of the synonymy given above. There is some doubt as to the colour when fresh, as this was not mentioned by any of the collectors. *P. hirneoloides* is coloured dingy orange by Cooke in 'Mycographia,' but is described by Berkeley as having the disc red. Colour, however, is not necessary for the recognition of this remarkable species. The name *P. dochmia* has 1 page priority over *P. hirneoloides*.

PEZIZA (§ DISCINA) INÆQUALIS, *Berk. & Curt. in Journ. Linn. Soc. (Bot.)* vol. x. (1869) p. 365; *Cooke, Mycogr.* fig. 204 (very inaccurate; the outside of the ascophore is whitish, not orange as represented, and the spores are too narrow); *Sacc. Syll.* viii. n. 258.

Sessile, margin at first incurved, gradually expanding until almost or quite plane, often wavy or inclined to be cochleate, rather fleshy, 5–8 cm. across; disc even, deep orange, much cracked when dry, externally whitish, adpressedly tomentose, shortly narrowed to a central point of attachment; hypothecium narrow, yellowish, of very densely interlaced hyphæ; these become

hyaline and looser to form the excipulum, becoming densely packed and coloured to form the cortex, many of the cells running out in groups to form the tomentoso-granular exterior; asci cylindrical, apex rounded and not blue with iodine, narrowed below into a slender pedicel, wall rather thick, about 390 × 15–16 μ; spores 8, 1-seriate, hyaline, smooth, continuous, inæquilaterally elliptical, often guttulate, 25 × 11–12 μ; paraphyses slender, septate, only slightly thickened at the apex.

Apparently having grown on rotten wood. Cuba (*Wright*, n. 187).

Superficially closely resembling *Peziza aurantia*, but distinguished by the smooth spores. Not a *Phillipsia* as suggested by Berkeley.

PEZIZA (§ DISCINA) PALMICOLA, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 364; *Cooke, Mycogr.* p. 145, fig. 245.

Sessile, fixed by a contracted central point, margin at first incurved, finally expanded and often more or less wavy or broken at the margin, substance rather thin; disc pale brown, externally whitish and slightly rugulose or granular, 3–6 cm. across; hypothecium, excipulum, and cortex pseudoparenchymatous, formed of hyphæ with vesicular inflations, the hypothecium small-celled and very compact, the remainder with very large cells; asci cylindrical, apex slightly truncate, the empty and shrivelled ones alone tinged blue with iodine, about 260 × 12 μ; spores 8, obliquely 1-seriate, hyaline, continuous, smooth, elliptical, ends obtuse, 15 × 8–9 μ; paraphyses slender, septate, clavate at the tips.

On rotten palms. Cuba (*Wright*, n. 300).

Allied to *Peziza repanda*, but differing in the smaller spores and in the larger vesicular cells forming the excipulum.

PEZIZA (§ DISCINA) ADNATA, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 364; *Cooke, Mycogr.* p. 152, fig. 259.

Sessile, plane, closely adnate by a broad base, the margin alone free and slightly upraised; disc even, umber- or blackish-brown, 1·5–2·5 cm. across; hypothecium, excipulum, and cortex consisting of densely interwoven hyaline hyphæ, homogeneous; asci cylindrical, apex rounded, the old and empty ones alone pale blue throughout the length with iodine, about 270 × 14–16 μ; spores 8, obliquely 1-seriate, hyaline, continuous, epispore densely covered

with minute hemispherical warts, 25–28 × 12–14 μ; paraphyses slender, septate, slightly expanded at the tips.

Exsicc. Fungi Cubenses Wrightiani, n. 658.

On rotten logs in dense palm-woods. Cuba (*Wright*, n. 212).

As remarked by Berkeley, the present species resembles a *Psilopezia* (=*Rhizina*) in being quite plane and dingy in colour, but differs from the last-named genus in the free and more or less upraised margin of the ascophore. Thin, cartilaginous, and almost translucent when dry, and in this condition the hymenium is minutely granulated when seen under a good lens.

Peziza (§ Discina) lechria, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 103; *Cooke, Mycogr.* p. 128, fig. 2 2.

Ascophore sessile, but narrowed to a very short, more or less lateral point of attachment, oblique, margin usually incurved, substance somewhat gelatinous and rather thin, rigid when dry; disc bay, externally darker and minutely granulose, 1–2 cm. high, about 1 cm. broad; hypothecium formed of densely interwoven hyphæ, which become loosely arranged and form a spongy hypothecium, becoming dense again in the cortex, which gives off little groups of cells to form the granular exterior; asci cylindrical, apex rounded, not blue with iodine; spores 8, 1-seriate, hyaline, smooth, continuous, elliptical, ends rather narrowed, then truncate, 16–18 × 9 μ; paraphyses slender, septate, slightly thickened and brown at the tips.

Otidea lechria, Sacc. Syll. viii. n. 360.

On very rotten wood. Peradeniya, Ceylon (*Thwaites*, n. 111).

Distinguished by the oblique form and subgelatinous consistency of the ascophore.

Peziza (§ Humaria) epitricha, *Berk. in Hook. Lond. Journ. Bot.* vol. ii. (1843) p. 516. (Pl. XVIII. fig. 22.)

Gregarious or crowded; sessile, attached by a broad base from which stout, brownish, septate hyphæ extend into the substratum; entirely dark red, fleshy, the thick margin and for some distance down the outside of the ascophore glabrous; at first closed, finally expanding until the disc is only slightly concave, often irregular in form due to lateral pressure, 1–1·5 mm. across; entirely parenchymatous; cells irregularly polygonal, and increasing in size from the hypothecium to the cortex, where they

are 25–35 μ in diameter, the basal cortical cells giving origin to the spreading hyphæ; asci cylindrical, apex somewhat truncate, not blue with iodine, about 240×13 μ; spores 8, obliquely 1-seriate, hyaline, continuous, smooth, elliptical, ends narrowed, usually 2-guttulate, 23–25×10 μ; paraphyses slender, septate, expanding into a clavate or pyriform coloured apex, 6–8 μ broad.

Humaria epitricha, Sacc. Syll. viii. n. 460.

On rotten wood. Uitenhage, S. Africa (*Zeyher*, n. 58).

Very closely allied to *Peziza carbonigena*, Berk. (*Humaria carbonigena*, Sacc. Syll. viii. n. 506), if in reality distinct, differing mainly in the smaller size of the ascophore and larger cortical cells.

Peziza (§ Humaria) flavotingens, *Berk. & Broome, in Journ. Linn. Soc. (Bot.)* vol. xiv. (1875) p. 104; *Cooke, Mycogr.* p. 23, fig. 38.

Gregarious; ascophores springing from a spreading, floccose mycelium, narrowed below into a short, stem-like base, closed at first, then expanding until saucer-shaped, rather fleshy, entirely pale yellow, externally minutely pulverulent or granular, due to the projection of groups of cells springing from the cortex, up to 1 cm. across, often smaller; hypothecium, excipulum, and cortex formed of rather stout, hyaline, intricately interwoven hyphæ; asci narrowly clavate, apex somewhat pointed, about 80×7 μ; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, elliptical, 11–12×5 μ; paraphyses rather stout, hyaline, with scattered inflations, but the apex not consistently thickened.

Humaria flavotingens, Sacc. Syll. viii. n. 501.

Ceylon.

I should consider the present species as a typical *Peziza*. The structure and granular exterior of the ascophore are against its retention in the genus *Humaria*.

Peziza (§ Humaria) Muelleri, *Berk. in Journ. Linn. Soc. (Bot.)* vol. xiii. (1873) p. 176; *Cooke, Mycogr.* fig. 26.

Gregarious or sometimes crowded; sessile, rather fleshy, at first closed, gradually expanding until plane, often more or less umbilicate, and margin frequently irregular; disc deep orange or red, externally paler, the obtuse margin glabrous, 1–2 mm. diameter; cortical cells below the margin giving origin to numerous septate hyaline hyphæ, which attach the fungus to the soil; hypo-

thecium, excipulum, and cortex formed of hyaline, irregularly polygonal cells, which gradually become larger towards the cortex; asci narrowly cylindrical, apex obtuse, about $250 \times 10\,\mu$; spores 8, 1-seriate, hyaline, continuous, smooth, elliptic-oblong, ends obtuse, often 1–2-guttulate, $19–22 \times 7–8\,\mu$; paraphyses very slender, expanding into a pyriform or clavate tip, $5–6\,\mu$ thick.

Humaria Muelleri, Sacc. Syll. viii. n. 455.

On the ground. Plenty Creek, Australia (*Mueller*, n. 9); Melbourne (*F. Reader*, n. 23).

Threads of the mycelium abundant, binding the particles of sand, very variable in thickness (*Berkeley*).

PEZIZA (§ HUMARIA) SCATIGENA, *Berk. & Curt. in Journ. Linn. Soc. (Bot.)* vol. x. (1867) p. 366; *Cooke, Mycogr.* fig. 72.

Gregarious; closed at first, then gradually expanding, but the margin more or less persistently incurved, rather fleshy, sessile, 3–6 mm. broad; disc blackish-purple with a tinge of green when fresh, smooth and even, externally pallid or whitish, minutely pulverulent or granular; substance parenchymatous; asci cylindrical, apex somewhat truncate; spores 8, at first obliquely 1-seriate, becoming irregularly 2-seriate, and the ascus clavate just before dehiscence, smooth, continuous, hyaline (in all the specimens examined the spores are now pale brown, but whether this is normal or due to age or preservatives cannot be determined), wall thick, broadly elliptical, $23–27 \times 11–13\,\mu$; paraphyses slender, tips thickened.

Humaria scatigena, Sacc. Syll. viii. n. 588.

Exsicc. Fungi Cubenses Wrightiani, n. 667.

On dung. Cuba (*Wright*, n. 636).

The immature asci become blue throughout their length with a solution of iodine, whereas the mature asci are not coloured at all by the same treatment.

PEZIZA (§ HUMARIA) SPISSA, *Berk. in Grevillea*, vol. iv. (1875) p. 152; *Cooke, Mycogr.* fig. 79.

Ascophore closed at first, then gradually expanding until plane, or sometimes slightly convex and the margin drooping, rather fleshy, often more or less lobed or incised at the margin, but sometimes also quite entire; disc even, bay-brown, externally paler and minutely scurfy or granular, narrowed into a very short, stout, whitish, stem-like base, ¾–2 cm. across; substance entirely

parenchymatous; cells irregularly polygonal, rather small, very dense in the cortex and running out in groups to form the minute external granulations; asci cylindrical, apex rounded and not blue with iodine, but at certain stages the whole of the asci and paraphyses are tinged blue, 270–300 × 17–18 μ; spores 8, obliquely 1-seriate, hyaline, continuous, smooth at first, but very finely but distinctly granular at maturity, often 2-guttulate, 20–24 × 12–14 μ; paraphyses numerous, slender, apex clavate and filled with brown colouring-matter.

Humaria spissa, Sacc. Syll. viii. n. 556.

On the ground. Alabama, U.S.A. (*Peters*, n. 6074).

Cooke says (Mycogr. p. 44), "Paraphyses cellular at the tips (fig. 79, *p*);" but this only means in reality that the colouring-matter is in some instances broken up into separate portions which are not, however, due to the presence of septa.

I consider the present species to be a *Peziza* as this genus is defined in Brit. Fungus-Fl. vol. iv. p. 424.

PEZIZA (§ HUMARIA) CREMICOLOR, *Berk. in Grevillea*, vol. iii. (1875) p. 151; *Cooke, Mycogr.* fig. 232.

Gregarious or crowded; closed at first, then expanding until shallowly saucer-shaped, thin, glabrous, sessile, and fixed by a central point, 1–2 mm. diameter, cream-colour; hypothecium and excipulum formed of hyaline interwoven hyphæ, which pass into a large-celled parenchymatous tissue in the cortex; asci cylindrical, apex rounded, about 200 × 10 μ; spores 8, obliquely 1-seriate, continuous, smooth, hyaline, elliptical, ends obtuse, 13–14 × 8 μ; paraphyses stout, septate, tips clavate.

On human dung. Lower Carolina, U.S.A. (*Ravenel*, n. 1748).

The paraphyses are unusually thick and distinctly septate. The species is a true *Humaria*, and not an *Ascobolus* as Berkeley thought it might probably prove to be.

PEZIZA (§ HUMARIA) BELLA, *Berk. & Curt. in Journn. Linn. Soc. (Bot.)* vol. x. (1869) p. 366; *Cooke, Mycogr.* fig. 58.

Gregarious; closed at first, then expanding until quite plane, the margin remaining very slightly upraised, sometimes rather umbilicate, thin, ½–1 cm. across when fully expanded; disc orange, externally paler and minutely granular, sessile, and attached by a central point; hypothecium formed of very densely interwoven slender hyphæ, these form a loose spongy tissue in the

excipulum, passing into a pseudo-parenchymatous tissue in the cortex, where groups of cells run out to form the external warts or granulations; asci cylindrical, narrowed into a slender, often crooked pedicel, apex rounded, wall thickened, not blue with iodine, about $200 \times 15\,\mu$; spores usually four in an ascus, sometimes fewer, never more, hyaline, continuous, broadly elliptical, for a long time smooth, finally very minutely and delicately rugulose, sometimes 1–2-guttulate, size rather variable, averaging $22 \times 12\,\mu$; paraphyses numerous, slender, only very slightly thickened at the tips.

Humaria bella, Sacc. Syll. viii. n. 528.

Exsicc. Fung. Cub. Wrightiani, n. 668.

On rotten wood. Cuba (*Wright*, n. 650).

Sometimes two or three spores only are present in an ascus; I have never seen more than four. The epispore is certainly very minutely, but distinctly, rugulose when quite mature.

PEZIZA (§ HUMARIA) USTORUM, *Berk. & Broome in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 105; *Cooke, Mycogr.* fig. 61.

Gregarious, or sometimes crowded; globose at first, the disc gradually expanding until only slightly concave, rather fleshy; 1–2 mm. high and broad; disc crimson, externally brown, rugulose, the obtuse margin and for some distance down the outside glabrous; the lower cortical cells giving origin to numerous hyaline septate hyphæ, 6–8 μ thick, which fix the fungus to the substratum; hypothecium and excipulum parenchymatous, the component cells gradually becoming larger towards the cortex, where they measure from 40–60 μ diameter, irregularly polygonal, hyaline; asci narrowly cylindrical, narrowed below into a slender pedicel, apex rounded, not blue with iodine, $300 \times 14\,\mu$; spores 8, obliquely or almost vertically 1-seriate, continuous, hyaline, smooth, broadly elliptical, ends obtuse, often 1–2-guttulate, $22–25 \times 10–12\,\mu$; paraphyses slender, septate, apex suddenly thickened and cylindrical, exactly resembling a reed-mace.

Humaria ustorum, Sacc. Syll. viii. n. 453.

On burnt earth. Habgalla, Ceylon (*Thwaites*, n. 279).

A fine and very distinct species, readily recognized by the peculiar paraphyses, which exactly resemble a reed-mace in miniature.

A fungus found growing on burnt earth near Berlin was at one time supposed by Rehm to be the same as *P. ustorum*, and was

named, with a query, *Leucoloma ustorum* (B. & Br.), Rehm, Ascom. n. 804. Portions of this same gathering, made by Sydow, were issued in Rabenh.-Winter, Fung. Eur. n. 3376, and in Syd. Myc. March. n. 779, and called *Leucoloma ustorum*, Rehm, omitting the query. Rehm has discovered that this species is not identical with *P. ustorum*, Berk. & Broome, and has called it *Pyronema subsanguineum*, Rehm, Krypt.-Flora, n. 5633.

PEZIZA (§ GEOPYXIS) HARMOGE, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 104; *Cooke, Mycogr.* fig. 282. (Pl. XVIII. figs. 8, 9.)

Solitary; stipitate, closed at first, then becoming cup-shaped, margin straight, erect, glabrous; disc dark purple, externally rosy, up to 1 cm. across; stem slender, equal, about 1 cm. long, rosy and often with a tinge of green; flesh white; hypothecium, excipulum, and cortex homogeneous, consisting of densely interwoven hyphæ; asci cylindrical, attenuated downwards into a slender wavy pedicel, apex rounded and not turned blue with iodine, wall thick, averaging $300 \times 16\,\mu$; spores 8, 1-seriate, hyaline, continuous, smooth, elliptic-oblong, ends obtuse, $24–25 \times 12–13\,\mu$; paraphyses numerous, very slender, cylindrical.

Geopyxis Harmoge, Sacc. Syll. viii. n. 212.

On very rotten twigs. Peradeniya, Ceylon (*Thwaites*, n. 1061).

PEZIZA (§ GEOPYXIS) LÆTICOLOR, *Berk. & Broome in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 104.

Scattered or gregarious; ascophore at first closed, the disc gradually expanding, finally plane or slightly convex, sometimes umbilicate, fleshy; disc red, externally paler, glabrous, 2–3 mm. across, sessile but narrowed to a central point of attachment; substance of ascophore consisting entirely of hyaline, slender, interwoven hyphæ; asci cylindrical, apex rounded, not blue with iodine, $200 \times 15\,\mu$; spores 4 in an ascus, vertically 1-seriate, smooth, hyaline, continuous, broadly elliptic-oblong or elliptical, ends obtuse, usually 2-guttulate, $23–26 \times 13–15\,\mu$; paraphyses septate, cylindrical, about $3\,\mu$ thick, tips very slightly or often not at all thickened.

Humaria læticolor, Sacc. Syll. viii. n. 450.

On sticks. Dolosbagey and Peradeniya, Ceylon (*Thwaites*, n. 579).

The present species is a true *Mollisia*, growing on wood, and not a *Humaria*.

PEZIZA (§ GEOPYXIS) CRENULATA, *Berk. & Broome in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 104; *Cooke, Mycogr.* fig. 270.

Gregarious; sessile or narrowed into a very short, central, stem-like point, rather thin, glabrous, closed at first, gradually expanding until plane, usually umbilicate, margin often remaining slightly incurved, frequently slightly irregular or crenulate; disc pale orange, externally paler, rugulose, the wrinkles spreading from the point of attachment of the ascophore, 4 mm. to 1 cm. across; hypothecium, excipulum, and cortex composed of slender, hyaline, thick-walled, densely interwoven hyphæ; asci cylindrical, apex obtuse, about $180 \times 10\,\mu$; spores 8, 1-seriate, hyaline, continuous, smooth, elliptical, $17–20 \times 7–10\,\mu$, often 2-guttulate; paraphyses numerous, very slender, sometimes branched, tips not thickened.

Humaria crenulata, Sacc. Syll. viii. n. 511.

On fallen branches. Peradeniya, Ceylon (*Thwaites*, nn. 8 & 579).

A true *Helotium*, having the characteristic structure of the ascophore present in that genus, and growing on wood. One of the largest and finest species included in the genus. The margin of the ascophore is often minutely crenulate, but not constantly so as might be imagined from the specific name.

PEZIZA (§ GEOPYXIS) EMARGINATA, *Berk. & Broome in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 104. (Pl. XVI. fig. 6.)

Plane, discoid, with a very slightly upraised margin, everywhere glabrous, somewhat fleshy; disc deep orange, becoming much cracked when dry, externally paler, wrinkled and corrugated irregularly when dry, due to contraction, attached by a broad base, up to 3 cm. across; hypothecium formed of densely interwoven, hyaline, septate hyphæ about $4\,\mu$ thick; these form an exceedingly open weft in the excipulum, and becoming densely crowded and parallel to form the cortex, thickness everywhere about equal; asci cylindrical, apex obtuse, not blue with iodine, narrowed below into a somewhat slender pedicel, 8-spored, about $300 \times 14–15\,\mu$; spores uniseriate, hyaline, continuous, smooth, elliptic-

oblong, ends truncate, 25–30×9–12 μ; paraphyses very slender, not thickened at the tips.

On rotten wood. Central Province, Ceylon (*Thwaites*, n. 1052).

In describing the present species, Berkeley gives the habitat as "on the ground or on very rotten wood." All the specimens in Berkeley's herbarium have grown on wood.

Superficially closely resembling *Phillipsia Venezuelæ*, Berk. & Curt., but sufficiently distinct in the form of the spores and structure of the cortex.

Peziza (§ Geopyxis) Geaster, *Berk. & Broome in Ann. & Mag. Nat. Hist.* ser. III. vol. vii. (1861) p. 449, & ser. III. vol. xviii. (1866) p. 125, t. 4. fig. 26; *Cooke, Mycogr.* fig. 144.

Lachnea Geaster, Phillips, Brit. Disc. p. 210; Sacc. Syll. viii. n. 693.

Sepultaria sepulta, Massee, Fungus-Flora, iv. p. 389.

An examination of the type of this species proves it to be identical with *Peziza sepulta*, Fries, Nov. Symb. Myc. p. 126 (1851).

Berkeley's specimens are slightly smaller than those of *P. sepulta*, sent by Fries to Berkeley, and now in Herb. Kew, but the two certainly belong to the same species, and Fries' name has priority.

The British specimens were collected at Wentworth by Mr. J. Henderson.

Peziza (§ Geopyxis) insititia, *Berk. & Curt. in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 103; *Cooke, Mycogr.* p. 116, fig. 201. (Pl. XVI. figs. 26, 27.)

Gregarious; ascophore rather deeply cup-shaped, narrowed at the base, 1–1·5 cm. high and wide; substance thin, entirely straw-colour when young, sometimes becoming darker with age; externally also the stem clothed with flattened, acuminate, scale-like hairs, each composed of a bundle of slender hyphæ; scales on stem and exterior of cup soon disappearing, those at the margin persistent, 2–3 mm. long, erect; stem slender, sometimes longitudinally wrinkled, variable in length, 1–3 cm.; excipulum homogeneous throughout, composed of very slender, intricately interwoven hyphæ; asci cylindrical, apex rounded and not blue with iodine, attenuated below into a long pedicel, averaging 400×15 μ; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, narrowly elliptic-fusiform, ends pointed, slightly inæqui-

lateral, 41–45 × 11–12 μ; paraphyses very slender, irregularly branched, tips not thickened.

Trichoscypha insititia, Sacc. Syll. viii. n. 648.

On dead wood and branches. Ceylon (*Thwaites*, n. 1051); Bonin Is. (*U. States Expl. Exp.*).

When the erect marginal hairs alone remain, the ascophore resembles a gigantic moss capsule with an erect peristome.

PEZIZA (§ SARCOSCYPHA) CUBENSIS, *Berk. & Curt. in Journ. Linn. Soc. (Bot.)* vol. x. (1869) p. 366; *Cooke, Mycogr.* p. 79, fig. 144. (Pl. XVIII. fig. 2.)

Sessile, applanate, rather fleshy, 3–6 mm. across; disc crimson or orange-red; externally paler, and sprinkled, especially near the margin, with thick-walled, ventricose, 1–3-septate, pointed, dark brown hairs 75–200 × 12–19 μ; shorter, obtuse hairs are intermixed at times, but not constantly present, base of hairs narrowed and sometimes branched, at others more or less bulbous; cortex parenchymatous; asci cylindrical, apex obtuse, not blue with iodine, about 220 × 14–15 μ; spores 8, 1-seriate, hyaline, continuous, broadly elliptical, ends obtuse, covered with rather large rounded warts, 16–21 × 11–13 μ; paraphyses slender, septate, tips clavate or pyriform.

Lachnea cubensis, Sacc. Syll. viii. n. 711.

Peziza (§ *Sarcoscypha*) *texensis*, Berk. & Curt. in Grevillea, vol. iii. (1875) p. 154; Cooke, Mycogr. p. 80, fig. 145.

Lachnea texensis, Sacc. Syll. viii. n. 738.

Peziza stictica, Berk. & Curt. in Journ. Linn. Soc. (Bot.) vol. x. (1869) p. 367; Cooke, Mycogr. fig. 135.

Sarcoscypha stictica, Sacc. Syll. viii. n. 718.

Exsicc. Fung. Cub. Wrightiani, n. 677.

On logs and on the ground. Cuba (*Wright*, nn. 380, 643); Texas (*Wright*, n. 3134).

The three species given above are identical in structure; the spores are slightly larger in the Texas specimen, but there is no other difference. The hairs are incorrect in both figures in 'Mycographia.'

PEZIZA (§ SARCOSCYPHA) BADIO-BERBIS, *Berk. in herb., Grevillea*, vol. viii. (1879) p. 61.

Lachnea badio-berbis, Sacc. Syll. viii. n. 669; Cooke, Handb. Austral. Fungi, p. 260.

PEZIZA (§ SARCOSCYPHA) MARGARITACEA, *Berk. in herb.*; *Cooke, Mycogr.* p. 73, fig. 132; *Grevillea*, vol. iii. (1875) fig. 219 (ascus and spores).

Lachnea margaritacea, Sacc. Syll. viii. n. 700; Cooke, Handb. Austral. Fungi, p. 261, fig. 155.

Examinations of type-specimens show that the two species named above are synonyms of each other, and further that both are identical with the old well-known species, *Peziza scutellata*, Linn. Fl. Suec. ed. 2, no. 1272, p. 458 (1755).

PEZIZA (§ SARCOSCYPHA) ALPHITODES, *Berk. in Grevillea*, vol. iii. (1875) p. 153; *Cooke, Mycogr.* p. 58, fig. 101. (Pl. XVI. fig. 16.)

Gregarious, stipitate; ascophore closed at first, then hemispherical or saucer-shaped, thin, margin minutely fimbriate under a lens, otherwise glabrous or even, entirely pallid or pale tan (when dry), 3–4 mm. across; stem slender, often wavy, smooth, up to 1 cm. long; cortex parenchymatous, cells narrow and elongated, running out at the margin into cylindrical, obtuse hyphæ, which are often minutely rough externally with particles of lime, $60–80 \times 5–6\,\mu$; asci cylindric-clavate, apex slightly narrowed, not blue with iodine, 8-spored; spores irregularly 2-seriate, narrowly cylindric-fusiform, hyaline, continuous, smooth, $10–15 \times 2{\cdot}5\,\mu$; paraphyses filiform.

Sarcoscypha alphitodes, Sacc. Syll. viii. n. 635.

On bark among moss. Boston, U.S.A. (*Murray*, n. 6230).

Berkeley states that the ascophore and stem are "slightly hispid." This character I could not discover, the plant appearing to be perfectly glabrous with the exception of the margin. Cooke's figure in 'Mycographia,' purporting to be natural size, is too large, as are also the spores. Belongs to the genus *Ciboria*.

PEZIZA (§ SARCOSCYPHA) SEMITOSTA, *Berk. & Curt. N. Amer. Fung.* n. 723, *in Grevillea*, vol. iii. (1875) p. 153. (Pl. XVI. fig. 19.)

Solitary or in small clusters; ascophore at first globose and closed, then expanding, the margin remaining for some time incurved; substance thin, whitish; disc dark brown or bay, often cracking when mature, externally brown, densely pilose, running out into a more or less elongated, stout, rugulose, stem-like base, 3–4 cm. across; hypothecium and excipulum formed of thick-walled, colourless, closely interlaced hyphæ $5–6\,\mu$ thick;

these pass into a brownish large-celled parenchymatous cortex, densely clothed with straight, stout, cylindrical, blunt, septate hyphæ, which often spring from an inflated basal cell, clear brown, tip often paler, 300–400 × 14–20 μ; asci cylindrical, apex rounded, 8-spored; spores 1-seriate, continuous, hyaline, smooth, often guttulate, elliptical, ends narrowed, 28–32 × 12 μ; paraphyses stout, septate, the clavate tips brownish.

Macropodia semitosta, Sacc. Syll. viii. n. 642.

Peziza pubida, Berk. & Curt. in Grevillea, vol. iii. (1875) p. 153; Cooke, Mycogr. fig. 110.

Macropodia pubida, Sacc. Syll. viii. n. 641.

Exsicc. Ellis & Everh. N. Amer. Fung. n. 2740; Ellis, N. Amer. Fung. n. 1269; Rab.-Winter, Fung. Eur. n. 3275.

On the ground. Pennsylvania, U.S.A. (*Michener*, n. 3936); Alabama (*Peters*, n. 6075).

Closely allied to *Peziza rhytidia*, Berk., distinguished by the thicker hyphæ of the excipulum, and the straight, much longer and stouter hairs on the surface; also the much thicker, brown paraphyses.

PEZIZA (§ MOLLISIA) BRASSIÆCOLA, *Berk. in Grevillea*, vol. iii. (1875) p. 157. (Pl. XVIII. fig. 25.)

Gregarious; rather thin, soft closed at first, then expanding until saucer-shaped, often wavy, sessile, glabrous, everywhere rufous to chestnut-brown, 1–2 mm. diameter; excipulum consisting of a small-celled parenchymatous tissue; asci cylindrical, apex rounded, not blue with iodine, 70–75 × 8 μ; spores 8, obliquely or vertically 1-seriate, hyaline, continuous, smooth, elliptical, ends obtuse, usually 1-guttulate, 9–10 × 6–7 μ; paraphyses slender, not thickened at the tips.

Pezizella brassiæcola, Sacc. Syll. n. 1176.

On dead cabbage-stems. New England, U.S.A. (*Sprague*, n. 5407).

The present species is a true *Mollisia*, as indicated by Berkeley. Saccardo's genus *Pezizella* cannot possibly stand other than as a section of *Mollisia*, from which it only differs in the clear bright colour of the ascophore, and even this one feeble generic character merges into *Mollisia*, as restricted by Saccardo.

PEZIZA (§ MOLLISIA) TAXODII, *Berk. in Grevillea*, vol. iv. (1875) p. 159. (Pl. XVIII. figs. 28–30.)

Scattered or gregarious, sessile, somewhat erumpent, seated

on a white powdery layer on the bark of the matrix; when young elongated like an *Hysterium*, margin incurved from opposite sides and concealing the disc, finally expanded, circular, concave; disc pale grey, externally black, glabrous, 1–2 mm. diameter; substance of ascophore formed of slender interwoven hyphæ, passing into a blackish grumous cortex; asci cylindric-clavate, thick-walled, not blue with iodine, containing 4–6–8 spores; spores broadly elliptical or ovate, 3–5–7-septate, then fenestrate, slightly or not at all constricted at the primary transverse septa, hyaline at first, then becoming brown; $35–45 \times 17–21\,\mu$ when only four in an ascus, smaller in size when 6–8 in an ascus; paraphyses very slender, septate, sometimes branched.

Blitrydium Taxodii, Sacc. Syll. viii. n. 3306.

Hysterium hiascens, Berk. & Curt. in Grevillea, iv. (1875) p. 11.

Blitrydium hiascens, Sacc. in Michelia, i. 417; Syll. Fung. viii. n. 3295.

On *Taxodium distichum* (=*T. mucronatum*), on *Quercus bicolor*, and on *Celtis occidentalis*: Upper Carolina, U.S.A. (*Ravenel*, nn. 633, 5833, 3416, and 3321; on ticket of last no. is "sent to Prof. Ed. Tuckerman as a lichen; he says—a fungus"). On bark, Italy (*Saccardo*).

Looking like a species of *Hysterium* when young. Berkeley's spore measurements are too large. I have not seen spores more than $45\,\mu$ long, even when large and only four in an ascus. There is an abundance of material of both *Peziza Taxodii*, Berk., and of *Hysterium hiascens*, Berk. & Curt., and the two are absolutely identical in every respect.

PEZIZA (§ ENCŒLIUM) RUSSA, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 106. (Pl. XVIII. fig. 19.)

Fasciculate or subsolitary, closed by the incurved margin at first, then expanding and often somewhat wavy, bright rust-colour, or sometimes reddish-brown, externally rather coarsely furfuraceous, due to the presence of crowded, short, moniliform strings of brown cells, $5–6\,\mu$ diameter, which spring from the cortical cells, and are most abundant near the margin, about 1 mm. across; hypothecium and excipulum formed of coloured interwoven hyphæ, which pass into a small-celled, brown, parenchymatous cortex; asci narrowly cylindric-clavate, apex rounded, not coloured blue with iodine, $45–50 \times 5\,\mu$; spores 8, irregularly

2-seriate, hyaline, continuous, smooth, cylindrical, ends obtuse, slightly curved, 7 × 1·5–2 μ; paraphyses slender, not appreciably thickened upwards.

Cenangium russum, Sacc. Syll. viii. n. 2340.

On bark. Central Province, Ceylon (*Thwaites*, n. 1064).

A fine and distinct species, marked by its bright rust-colour and small, sausage-shaped spores.

PEZIZA (§ ENCŒLIA) USTALIS, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 152. (Pl. XVIII. figs. 20, 21.)

Crowded, rarely scattered, stipitate; ascophore at first closed and the margin strongly incurved, then becoming cup-shaped and regular, finally quite plane and flexuous; substance rather thin, pliant, and translucent when young and moist, hymenium clear brown, externally reddish-brown and very minutely furfuraceous, at length altogether blackish, up to 2 mm. across when plane; stem short, stout, blackish; hypothecium and excipulum formed of slender, coloured, interwoven hyphæ, passing into a small-celled brown parenchymatous cortex; asci cylindric-clavate, 45–50 × 4–5 μ, not at all blue with iodine; spores 8, irregularly 2-seriate, hyaline, continuous, smooth, cylindrical, ends obtuse, slightly curved, 4–5 × 1·5 μ; paraphyses slender, not thickened upwards.

Cenangium ustale, Sacc. Syll. n. 2435.

On fallen branches. Alabama, U.S.A. (*Peters*, n. 6068).

Apparently erumpent, bursting through the bark. When young and translucent, there is a tinge of reddish-purple along with the brown. Superficially resembling *Cenangium Cerasi*, Massee, but quite distinct in the continuous, hyaline, smaller spores.

PEZIZA (§ LACHNEA) COPROGENA, *Berk. & Broome, in Trans. Linn. Soc.* ser. II. (*Bot.*) vol. ii. (1883) p. 69. (Pl. XVII. figs. 28, 29.)

Gregarious or crowded, dingy orange, closed at first, then plane or slightly convex, clothed externally, and especially near the margin, with slightly tinted, conical, septate, rather thick-walled hairs 100–200 × 8–12 μ, often thick at the base only, and becoming abruptly slender and cylindrical; excipulum parenchymatous, cortical cells large, polygonal; asci cylindrical, abruptly contracted into a very short pedicel, wall thick, apex rounded, not blue with iodine, about 180 × 17 μ; spores 8, 1-seriate, hyaline, continuous, smooth, elliptic-oblong, ends obtuse, wall thick, about 25 × 12 μ; paraphyses slender, septate, apex clavate.

Lachnea coprogena, Sacc. Syll. viii. n. 735.
On dung. Brisbane (*Bailey*).

PEZIZA (? DASYSCYPHA) ATRO-CITRINA, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xiv. (1875) p. 106. (Pl. XVIII. figs. 26, 27.)

Gregarious; sessile, at first closed, then expanding until saucer-shaped, margin permanently erect or slightly incurved; disc blackish, externally pale yellow, minutely pilose, hairs most numerous and best developed near the margin, where they are arranged in fascicles, which run for some distance down the outside of the ascophore as vertical lines; hairs obtuse, septate, cylindrical, pale yellow, rough, especially near the apex, with minute particles of oxalate of lime, usually curved, 80–120 × 5–6 μ, becoming shorter towards the base of the ascophore; cortical cells small, narrow, much elongated in the direction from base to margin; asci clavate, apex slightly narrowed, not blue with iodine, 250 × 9–10 μ; spores 8, irregularly 2-seriate, cylindrical, or the apex sometimes very slightly thickened, and forming a narrowly clavate shape, hyaline, 3–5-septate at first, finally multiseptate, 45–50 × 6 μ, straight or slightly curved; paraphyses very slender, not at all thickened at the tips, very numerous.

Velutaria atro-citrina, Sacc. Syll. viii. n. 2019.
On dead wood. Ceylon (*Thwaites*, n. 274).

Almost indistinguishable from *Dasyscypha melaxantha* (Fr.), Massee, under a lens, but very different in its fruit. When young the exterior is uniformly pilose, but as the ascophore expands the hairs are separated into fascicles, which form a minutely toothed margin, and often also forming parallel vertical ridges on the exterior. This arrangement is not uncommon in species having a pilose exterior.

PEZIZA (§ TAPESIA) PIGGOTII, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. II. vol. xiii. (1854) p. 464; *Phillips, Brit. Disc.* p. 106.

Gregarious or crowded, sessile, seated on a thin, downy, white hypothecium; subglobose and closed at first, then saucer-shaped, rather fleshy, 3–4 mm. across; disc pale brick-red, externally paler, glabrous; hypothecium and excipulum formed of branched, irregularly swollen hyphæ, which are often thickened at the point of bifurcation; these hyphæ become denser in the cortex, and give origin, below the margin, to slender, branched, aseptate

hyphæ, which attach the fungus to the substratum, and also form a thin subiculum; asci cylindrical, apex rounded, not becoming blue with iodine, about 160 × 9–10 μ; spores 8, obliquely 1-seriate, hyaline, smooth, continuous, elliptical, ends blunt, 15–17 × 8–9 μ; paraphyses numerous, very slender, not thickened at the tips.

Humaria Piggotii, Sacc. Syll. viii. n. 545; Massee, Brit. Fungus-Flora, vol. iv. p. 407.

On the plaster ceiling of a cottage. Chelmsford, England (*H. Piggot*).

Mycelium white, downy, but not spreading widely, running up the base of the hemispherical or cyathiform cups, which are about 2 lines broad, margin generally acute (*Berk. & Broome*).

PEZIZA (§ TAPESIA) ATRO-FUSCA, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 156. (Pl. XVI. fig. 28.)

Gregarious, entirely blackish-brown, with a suggestion of purple, rather fleshy; closed at first, then expanding, but the margin persistently more or less incurved (when dry); disc slightly concave; externally minutely granular, the granules arranged in lines, giving a ribbed appearance to the incurved margin; cortex parenchymatous, the cells running out in groups to form the external granulation; from the lower portion of the external surface of the ascophore numerous stout, septate, dark brown hyphæ proceed and attach the fungus to the substratum; asci narrowly cylindrical, apex rounded; spores 8, 1-seriate, continuous, smooth, elliptic-oblong, ends obtuse, often 1–2-guttulate, at first hyaline, then tinged pale olive, 8–10 × 4–5 μ; paraphyses numerous, slender, cylindrical.

Tapesia atro-fusca, Sacc. Syll. viii. n. 1537.

On rotten pine-wood. Alabama, U.S.A. (*Peters*, n. 6083).

The specimens are overrun with a dense pale ochraceous mould, which I think has no genetic connection with the *Peziza*, which under a pocket-lens looks like *Triblidium rufulum*. The present species appears to belong to the genus *Tryblidiopsis*, and closely allied to *T. Pinastri*, Karst., which is represented in the Kew herbarium from various parts of the United States. I have not seen the spores septate.

PEZIZA (§ TAPESIA) SCARIOSA, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 156. (Pl. XVI. fig. 29.)

Ascophores forming small, scattered patches consisting of

3–10 individuals, densely crowded or overlapping, and seated on an extended, brownish-black subiculum formed of stout, brown, septate hyphæ; ascophores 1–3 mm. diameter, circular in outline when isolated, but usually irregular from mutual pressure, very thin, at first closed, but soon becoming quite plane, entirely black; cortex parenchymatous, cells polygonal, brown, 10–12 μ diameter, the lower ones giving origin to stout hyphæ which pass into the subiculum; asci narrowly cylindric-clavate, apex rounded; spores 8, 1-seriate, continuous, smooth, hyaline, narrowly cylindric-fusoid, $12–13 \times 3{\cdot}5\,\mu$; paraphyses numerous, slender, agglutinated together.

Tapesia scariosa, Sacc. Syll. viii. n. 1544.

On dead branches in moist places. Lower Carolina (*Ravenel*, n. 1086).

Closely allied to *Peziza mollisioides*, Schw., but differing in the somewhat larger ascophores and spores. May possibly prove to be only a form of the last-named species. The spores are in some specimens tinged olive, but whether this is normal or the result of poisoning, &c., I cannot determine.

PEZIZA VERRUCULOSA, *Berk. & Curt. in Proc. Amer. Acad.* vol. iv. (1860) p. 127; *Cooke, Mycogr.* fig. 283. (Pl. XVII. fig. 32.)

Ascophore stipitate, subglobose and closed when young, then cup-shaped, finally becoming almost or quite plane; rather fleshy and rigid; entirely blackish-purple; disc even, cracked when dry; externally and the margin granular, due to the presence of densely crowded, coloured, obtuse, rather closely septate hairs, often constricted at the septa, $80–100 \times 9–12\,\mu$, these are collected in groups and form the granules; $\frac{1}{2}$–$1\frac{1}{2}$ cm. across; stem short and stout, sometimes almost absent, minutely granular; hypothecium, excipulum, and cortex formed of hyaline, densely interwoven septa which pass abruptly into the coloured, external hairs; asci cylindrical, wall thick, apex rounded and not blue with iodine; spores 8, 1-seriate, continuous, hyaline, smooth, broadly elliptical, ends obtuse, $12–13 \times 7–8\,\mu$; paraphyses slender, septate, coloured at the slightly thickened tips.

Geopyxis verruculosa, Sacc. Syll. viii. n. 227.

On stony hills. Arakamtchetchene Island, Behring Straits (U.S. North Pacific Expl. Exp.; *Wright coll.* n. 150).

PEZIZA SARMENTORUM, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xvi. (1875) p. 102; *Cooke, Mycogr.* p. 156, fig. 267; *Sacc. Syll.* viii. n. 322.

Gregarious, subgelatinous when moist, thin, entirely ochraceous (when dry), margin at first incurved, eventually becoming almost plane; disc even, or often rugulose or veined, externally minutely pulverulent, sessile, and attached by a broad base, 6–16 mm. broad; asci cylindrical, apex rounded, about 260 × 11–12 μ; spores 8, narrowly elliptical, ends somewhat narrowed, often 2-guttulate, hyaline, smooth, continuous, 16–19 × 7–8 μ; paraphyses slender, scarcely thickened at the apex.

On twigs and fallen leaf-stalks. Ceylon (*Thwaites*).

The substance of the entire ascophore is subgelatinous, and does not present, at least after being dried, any definite structure.

PEZIZA CARBONIGERA, *Berk. in Hook. f. Fl. Tasm.* ii. p. 274 (1860); *Cooke, Mycogr.* p. 19, fig. 29.

Gregarious, or generally crowded and irregular from mutual pressure, sessile and applanate; subglobose at first, then gradually expanding until plane or even slightly convex, often undulate; the disc varies from pale, clear yellow, through orange-yellow, to yellowish-brown, or even a tinge of flesh-colour, externally paler, extreme margin brownish; rather fleshy, 2–8 mm. across; hypothecium and excipulum consisting of interwoven, hyaline, septate hyphæ, which are swollen into large piriform or subglobose cells at intervals, passing into a parenchymatous cortex of irregular, polygonal cells, 10–18 μ diameter; these run out at the margin into short, septate, obtuse, brown cells; numerous brown, or sometimes almost hyaline, septate hyphæ spring singly or in clusters from the basal cortical cells and fix the fungus to the substratum; asci cylindrical, apex slightly truncate, not coloured blue with iodine, about 220 × 14–15 μ; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, elliptical, ends rather narrowed, usually 2-guttulate, 19–20 × 9–11 μ; paraphyses septate, apex clavate or piriform, 6–7 μ thick, containing red granules.

Humaria carbonigena, Sacc. Syll. viii. n. 506.

On burnt ground, rotten wood, masses of decaying leaves, &c. Tasmania (*Archer*); Melbourne, Australia (*Reader*, n. 52) Britain (*Berkeley*).

This species was founded on specimens collected in Tasmania; Australian localities were afterwards added, and finally British specimens were collected, agreeing in every particular with those from the Antipodes.

PEZIZA SUCCOSA, *Berk. in Ann. & Mag. Nat. Hist.* vol. vi. (1841) p. 358, t. 10. fig. 5; *Cooke, Mycogr.* p. 144, fig. 243; *Massee, Brit. Fungus-Flora*, iv. p. 438.

Sessile, closed, and with the margin incurved at first, then cup-shaped, usually regular, but sometimes more or less cochleate, rather fleshy, almost translucent when moist; disc pale waxy-brown, externally pale and minutely scurfy, 2–4 cm. across; giving out a yellow juice when broken; excipulum consisting of stout, somewhat nodulose, interwoven hyphæ; asci cylindrical, apex rounded, not blue with iodine, or a very slight tinge only when old and empty, about $300 \times 14\ \mu$; spores 8, 1-seriate, hyaline, continuous, elliptical, rather coarsely warted, $19–21 \times 11–12\ \mu$; paraphyses septate, becoming gradually clavate in the upper third of their length.

Galactinia succosa, Sacc. Syll. viii. n. 397.

Exsicc. Cooke, Fung. Brit. Exs. ser. II. n. 650; Thuemen, Myc. Univ. n. 1411; Roum. Fung. Gall. n. 3932; Roum. Fung. Sel. Exs. n. 5335; Phillips, Elv. Brit. n. 10.

On the ground in woods, mostly solitary.

England (*Berkeley, Cooke, Phillips*); Belgium (*Libert*); Switzerland (*Morthier*); France (*Sarrazin, Roumeguère*); New England (*Sprague*, n. 5327); Lower Carolina (*Ravenel*, n. 3279).

PEZIZA SALMONICOLOR, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. II. vol. xviii. (1866) p. 124; *Cooke, Mycogr.* fig. 48.

Gregarious; sessile, seated on a broad base and attached to the substratum by hyaline, septate hyphæ, which spring from the basal cortical cells; fleshy, concave, then plane or even slightly convex, margin adpressed; disc salmon-colour, 2–3 mm. diameter; excipulum tinged red, parenchymatous, cells polygonal or almost circular, $12–20\ \mu$ diameter; asci rather broadly clavate, narrowed to a slender base, apex somewhat truncate, about $180 \times 16\ \mu$; spores 8, irregularly 2-seriate in the widest part of the ascus, hyaline, smooth, continuous, elliptical, ends obtuse, $18–22 \times 10–12\ \mu$; paraphyses slender, septate, slightly clavate at the tip.

Humaria salmonicolor, Sacc. Syll. viii. n. 470; Massee, Brit. Fungus-Flora, iv. p. 420.

Damp ground, sides of ditches, &c. Woodnewton, England (*Berkeley*).

Characterized by the clavate asci and 2-seriate spores.

PEZIZA EXIDIIFORMIS, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. IV. vol. xv. (1875) p. 37; *Cooke, Mycogr.* p. 34, fig. 60.

Gregarious or crowded, sessile, but attached by a narrowed base, closed at first, becoming almost plane, often more or less wavy, rather fleshy, and inclined to be gelatinous when moist, up to 4 mm. across, entirely dingy purple, glabrous, disc marked with anastomosing ribs or wrinkles; excipulum and cortex parenchymatous, cells polygonal, 12–18 μ diameter; asci cylindrical, apex somewhat truncate, not becoming blue with iodine, 250–260 × 12–14 μ; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, broadly elliptical, ends obtuse, often 2-guttulate, 15–17 × 10 μ; paraphyses filiform, apex slightly clavate.

Humaria exidiiformis, Sacc. Syll. viii. n. 468; Massee, Brit. Fungus-Flora, iv. p. 418.

On silver sand, Cork (*Saunders*). On rotten wood, Stannage Park, England (*Broome*).

I consider the present species as belonging to the Bulgariæ, genus *Ombrophila*. The ascophore is narrowed into a stem-like base, is of a subgelatinous consistency when moist.

PEZIZA DECOLORANS, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 150; *Cooke, Mycogr.* p. 149, fig. 253; *Sacc. Syll.* viii. no. 329.

Sessile, obovate and closed at first, then expanding until broadly and shallowly funnel-shaped, somewhat cartilaginous, thin, margin usually persistently incurved; disc even, externally remarkably wrinkled or rugulose, entirely white at first, becoming pallid; $\frac{2}{3}$–$1\frac{1}{2}$ cm. across; hypothecium and excipulum formed of stout, intricately interwoven hyphæ, which pass into a pseudoparenchymatous cortex; asci cylindrical, apex obtuse and not at all blue with iodine, about 320 × 16–17 μ; spores 8, 18–20 × 8 μ, elliptical, smooth, continuous, hyaline, often 2-guttulate; paraphyses slender, slightly thickened upwards.

On the ground. Alabama, U.S.A. (*Peters*, n. 6059).

Remarkable for being entirely white at first, and for the strongly wrinkled exterior of the ascophore. The type specimens,

when soaked in water, are pale brown, but this may be due to age and preservatives. On the label Peters says, "white at first."

PEZIZA RHYTIDIA, *Berk. in Hook. f. Fl. Nov. Zeland.* vol. ii. p. 200, tab. cv. fig. 6 (1855); *Sacc. Syll.* viii. n. 331. (Pl. XVI. figs. 17, 18.)

Gregarious; ascophore subglobose and closed at first, then expanding and becoming cup-shaped, margin even or irregular, for some time incurved; substance thin, whitish, pliant, 1·5–5 cm. diameter, entirely blackish, often with a tinge of purplish-red; disc concave, even, or rugulose and cracked when old; externally minutely but densely velvety, ornamented with anastomosing, raised ribs which disappear towards the margin; stem variable in length, stout, lacunose like the outside of the ascophore, velvety or sometimes almost strigose, 1–5 cm. long, sometimes almost absent and expanded at the base; ascophore formed of slender, intricately interwoven hyphæ, which become tinged brown and parenchymatous at the cortex, finally running out into a densely interwoven weft of brown, septate hyphæ forming the external velvety pile; asci cylindrical, apex obtuse, not blue with iodine, wall thick; spores 8, 1-seriate, hyaline, smooth, continuous, obliquely elliptical and very slightly curved, $25 \times 10–11\,\mu$; paraphyses numerous, very slender, sometimes branched.

Peziza campylospora, Berk. in Hook. f. Fl. Nov. Zeland. vol. ii. p. 200 (1855).

Macropodia campylospora, Sacc. Syll. viii. n. 640.

Rhizina reticulata, Berk. & Broome, in Journ. Linn. Soc. (Bot.) vol. xiv. (1875) p. 103; Sacc. Syll. viii. n. 183.

Peziza (*Geopyxis*) *cinereo-nigra*, Berk. & Broome, Fungi of Brisbane, n. 56, in Trans. Linn. Soc. ser. II. (Bot.) vol. i. (1876) p. 404, tab. 46. figs. 16–18.

Geopyxis cinereo-nigra, Sacc. Syll. viii. n. 218.

On decayed wood, frequently on wood buried in the ground. New Zealand, Bay of Islands (*Dr. Hooker*); Banks of Kawatan in the interior (*Colenso*, nn. 2554 & 5053); Australia, Genoa River (*E. Reader*); Ceylon (*Thwaites*, n. 321); Neilgherries (*E. S. Berkeley*).

Examination of the type specimens shows that the four species enumerated above are identical in structure; the differences enumerated by Berkeley being due to differences in age and size only.

PEZIZA LACHNODERMA, *Berk. in Hook. f. Fl. Tasm.* ii. p. 274 (1860).

Gregarious or scattered, shortly but distinctly stipitate; stem black, especially at the base; margin at first incurved and almost closed, then expanding until nearly plane, but the margin persistently more or less upraised; externally pure white, densely downy, hairs thin-walled, cylindrical, obtuse, septate, hyaline, often very minutely rough with particles of lime, 70–100 × 5–6 μ, often slightly curved; sometimes the hairs disappear, except at the margin, leaving the exterior of the ascophore bald; disc yellow to deep orange-red; laterally compressed and closed when dry, 3–4 mm. diameter; asci clavate, apex slightly narrowed, blue with iodine, 60–70 × 6–8 μ; spores 8, irregularly 2-seriate, hyaline, smooth, continuous at first, then 1-septate (possibly 3-septate at maturity), linear-fusiform, usually slightly curved, ends acuminate, 23–30 × 2 μ; paraphyses slender, very slightly thickened at the tip and the point narrowed, delicately septate; hypothecium and excipulum formed of slender interwoven hyphæ which become converted into small, elongated hexagonal cells radiating from base to margin at the periphery.

Dasyscypha lachnoderma, Sacc. Syll. viii. n. 1804 (in part.).

Peziza melanopus, Berk. & Curt. Cuban Fungi, n. 674, in Journ. Linn. Soc. vol. x. (1869) p. 367.

Sarcoscypha melanopus, Sacc. Syll. viii. n. 634.

The type of *P. lachnoderma* is from Tasmania, on bark and branches (*Archer*). Other specimens in the herbarium are from Brisbane (*Bailey*, nn. 572 and 1804); Natal (*MacOwan*, nn. 156, 194, 1126). The type of *P. melanopus*, Berk. & Curt., from Cuba (*Wright*, n. 368), proves to be identical with *P. lachnoderma*. Not any of the specimens mentioned above are growing on bark or wood of conifers.

Dr. Rehm described in Grevillea, vol. iv. (1876) p. 169, under the name of *Peziza Ellisiana*, a minute *Peziza* growing on pine-bark, collected by J. B. Ellis at Newfield, New Jersey, U.S.A. This species was afterwards issued in Rehm's Ascom. n. 303 as *Dasyscypha Ellisiana*, Rehm. Some time afterwards Rehm sent out a new label for his Ascom. n. 303, in which he substituted the name *Dasyscypha lachnoderma* (Berk.), Rehm. This was unfortunate, as the American plant is quite distinct, differing from *P. lachnoderma*, Berk., more especially in the following points:—Ascophore smaller, not so distinctly stipitate; stem

not black, externally tinged yellowish-green; asci slightly broader, spores shorter and thicker, and in all the specimens I have examined continuous; always growing on bark or wood of conifers. Hence *Peziza Ellisiana*, Rehm, must stand as a species distinct from *P. lachnoderma*, Berk., with the following synonymy:—

Dasyscypha lachnoderma, Rehm, Ascom. n. 303; Sacc. Syll. viii. n. 1804 (in part.).

Exsicc. Rehm, Ascom. n. 303 (called *Dasyscypha Ellisiana*, Rehm; and afterwards changed to *Dasyscypha lachnoderma* (Berk.), Rehm).

Thuemen, Myc. Univ. n. 716 (called *Peziza Ellisiana*, Rehm).

Ravenel, Fung. Amer. Exs. n. 175 (called *Peziza lachnoderma*, Berk.).

Ellis & Everh. N. Amer. Fung. ser. II. n. 3231 (called *Peziza* (*Dasy.*) *lachnoderma*, Berk.).

PEZIZA RECURVA, *Berk. in Hook. f. Fl. Tasm.* p. 273 (1860); *Cooke, Mycogr.* p. 230, fig. 386. (Pl. XVII. fig. 3.)

Scattered or gregarious, globose and closed at first, then expanded and often umbilicate, margin drooping and often wavy; rather fleshy, sessile but narrowed below into a short stem-like base, glabrous, brown, paler when dry, 1–2 cm. across; asci cylindrical, apex obtuse, becoming very slightly tinged blue with iodine, apex not darker than the rest, $200 \times 16–17\ \mu$; spores 8, 1-seriate, hyaline, globose, rather coarsely warted, $14–16\ \mu$; paraphyses slender, very slightly thickened upwards, sparingly and delicately septate; hypothecium formed of slender, densely interwoven hyphæ, which become stouter and also interwoven in the excipulum.

Barlæa recurva, Sacc. Syll. viii. n. 443.

On damp ground. Tasmania (*Archer*).

Type specimen in Herb. Kew examined.

PEZIZA GLOBIFERA, *Berk. & Curt. Fungi Cubenses*, n. 669, *in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 336; *Cooke, Mycogr.* p. 21, fig. 34 (excl. syn. *Peziza sphæroplea*). (Pl. XVII. fig. 5.)

Gregarious, sessile, at first globose and closed, then expanding, but the margin usually remaining more or less incurved and often slightly notched or lobed, everywhere clear, bright yellow, externally glabrous, cartilaginous when dry, up to 1 cm. diameter;

hypothecium and excipulum formed of slender, densely interwoven hyphæ, which become parallel externally and run out into clavate tips; asci cylindrical, apex somewhat truncate, 150 × 11–12 μ; spores 8, 1-seriate, hyaline, persistently smooth, epispore rather thick, 8–10 μ diameter; paraphyses slender, cylindrical, sometimes very slightly thickened at the extreme apex, which is often slightly curved, rather longer than the asci.

Barlæa globifera, Sacc. Syll. viii. n. 431.

Exsicc. Fung. Cub. Wright. n. 669.

The type specimen was collected on sandy ground in Cuba by Wright (nn. 282 & 645); Ceylon (*Thwaites*, n. 1060).

Peziza sphæroplea, *Berk. & Cooke, in Bull. Buff. Soc. Nat. Sc.* (1875) p. 289. (Pl. XVII. fig. 6.)

Gregarious, sessile, rather fleshy, globose and closed at first, then expanding until almost or quite plane; margin sometimes wavy, entirely clear, deep yellow, ·5–1 cm. across; hypothecium and excipulum formed of densely interwoven hyaline hyphæ, which pass into a cortex of large polygonal cells, the external ones brownish, and giving origin below the margin to stout, brown, septate hyphæ which fix the plant to the ground; asci cylindrical, apex truncate, about 150 × 14–15 μ; spores 8, 1-seriate, hyaline, persistently smooth, 13–14 μ diameter; paraphyses slender, very slightly thickened upwards, delicately septate.

Peziza globifera, Cooke, Mycogr. p. 21.

Barlæa globifera, var. *sphæroplea*, Sacc. Syll. viii. n. 431.

On the ground, "Car. Inf. nn. 1991 & 2974." No collector's name.

Readily distinguished from *Peziza globifera* by the larger spores and the presence of hyphæ on the outside of the ascophore; these spring sometimes so near to the margin as to suggest the genus *Sphærospora* rather than *Barlæa* of Saccardo's arrangement.

Peziza exasperata, *Berk. & Curt. N. Amer. Fung.* n. 716, *in Grevillea*, iii. (1875) p. 152; *Cooke, in Bull. Buff. Soc. Nat. Sc.* (March 1875); *Cooke, Mycogr.* p. 15, fig. 21. (Pl. XVII. figs. 1, 2.)

Scattered, rarely crowded, sessile, globose and closed at first, then broadly open, but having the thick obtuse margin perma-

nently more or less upraised; disc crimson-lake or scarlet, externally paler and minutely warted or granulated, rather fleshy, 1–1·5 cm. diameter; hypothecium and excipulum consisting of densely interwoven hyphæ, becoming imperfectly parenchymatous at the cortex; asci cylindrical, apex obtuse, 150–160 μ; spores 8, 1-seriate, hyaline, smooth for some time, finally covered with minute acute warts, 12–14 μ; paraphyses slender, slightly thickened upwards, septate.

Barlæa exasperata, Sacc. Syll. viii. n. 420.

On burnt ground. Alabama (*Peters*).

Allied to *P. Wrightii*, Berk. & Curt. For distinctions between the two, see note under the last-named species.

Type specimen in Herb. Kew examined.

PEZIZA GRATA, *Berk. in Hook. f. Fl. Tasm.* vol. ii. p. 275 (1860). (Pl. XVII. fig. 15.)

Scattered or gregarious, stipitate, very soon plane, sometimes flexuous, almost translucent when moist, thin, pale orange, glabrous, about 1–2 mm. across; hypothecium and excipulum formed of slender hyphæ which run parallel from base to margin in the cortex; stem 1–2 mm. long, slender, paler than the ascophore, glabrous, usually buried in the woody matrix; asci narrowly cylindrical, apex obtuse and blue with iodine; spores 8, obliquely 1-seriate, continuous, hyaline, elliptic-fusoid, ends rather pointed, straight, usually furnished with a small oil-globule near each end, $10 \times 4{\cdot}5$–$5\ \mu$; paraphyses slender, tips not thickened.

Helotium gratum, Cooke, Austral. Fungi, p. 264; Sacc. Syll. viii. n. 918.

On dead wood. Tasmania (*Archer*).

In the type specimens the plants are growing on old weathered wood, and nestle in the chinks between the fibres, from which they spring; they are in some instances compressed, owing to not being raised out of the chink.

PEZIZA ALBO-CINCTA, *Berk. & Curt. N. Amer. Fung.* n. 720, *in Grevillea*, vol. iii. (1875) p. 154.

Neottiella albocincta, Sacc. Syll. viii. n. 776.

This species is certainly synonymous with *Peziza Polytrichi*, Schum. Enum. Plant. Sæll. Sept. et Or. p. 423 (1803) (not of Cooke, Mycogr. p. 30, fig. 50).

For a critical investigation relating to the synonymy of *Peziza Polytrichi*, Schum., and *Peziza rutilans*, Fr., respectively, see Grevillea, vol. xxii. (1894) p. 107.

PEZIZA SULCIPES, *Berk. in Hook. Lond. Journ. Bot.* vol. i. (1842) p. 141; *Cooke, Mycogr.* p. 115, fig. 199.

Trichoscypha sulcipes, Sacc. Syll. viii. n. 651.

Peziza Hindsii, Berk. in Lond. Journ. Bot. vol. i. (1842) p. 456; Cooke, Mycogr. p. 115, fig. 200.

Trichoscypha Hindsii, Sacc. Syll. viii. n. 652.

The two species enumerated above are synonyms of each other, and in turn both are synonymous with *Peziza tricholoma*, Mont. Ann. Sci. Nat. sér. II. vol. ii. (1834) p. 77, tab. 4. fig. 2.

The types of both Berkeley's species examined, also an authentic specimen of *P. tricholoma* sent by Montagne to Berkeley. The external fascicles of hairs are deciduous, especially those situated below the margin, hence the fungus soon becomes bald.

PEZIZA MARCHANTIÆ, *Berk. in Sm. Engl. Fl.* vol. v. p. 204 (1837). (Pl. XVII. fig. 25.)

Scattered or solitary, but fixed by a narrowed base, fleshy, becoming almost or quite plane, but often with the extreme margin upraised, glabrous, sometimes more or less wavy; pale yellowish-brown, disc usually darker when dry, 1–1·5 mm. diameter; excipulum parenchymatous, cells irregularly polygonal and largest towards the outside, where they measure 15–25 μ; asci elongated, narrowly cylindrical, tapering and often wavy at the base; spores 8, obliquely 1-seriate, hyaline, continuous, smooth, elliptic-oblong, $12–15 \times 3–4$ μ; paraphyses filiform, very slightly thickened upwards, hyaline, 3 μ thick at the tip.

Helotium Marchantiæ, Fries, Summa Veg. Scand. p. 356 (1846); Phillips, Brit. Disc. p. 164; Sacc. Syll. viii. n. 1012; Massee, Fungus-Flora, vol. iv. p. 267.

On fading *Marchantia polymorpha*. Whittlesea Mere (*Rev. M. J. Berkeley*).

There is a specimen of this species in the Kew Herbarium collected in Finland by Karsten.

PEZIZA PATERÆFORMIS, *Berk. in Hook. f. Fl. Tasm.* vol. ii. p. 276 (1860). (Pl. XVII. fig. 23.)

Scattered, sessile, but attached by a narrowed stem-like base, globose at first, soon becoming plane, and finally slightly convex, the extreme margin often remaining upraised, rather fleshy, glabrous, often more or less irregular in outline, 2–4 mm. across, yellowish-brown (when dry); cortex parenchymatous, cells small; asci cylindrical, apex rounded and coloured blue with iodine, wall rather thick, $160 \times 14\,\mu$; spores 8, obliquely 1-seriate, hyaline, smooth, for a long time continuous, finally 1-septate, straight or very slightly curved, cylindric-oblong, or the ends sometimes more or less pointed and inclined to be cylindric-fusiform, $27–30 \times 7–8\,\mu$; paraphyses numerous, slender, slightly thickened at the tips.

Helotium pateræforme, Cooke, Austr. Fung. p. 264; Sacc. Syll. viii. n. 1028.

Helotium aglæosporium, Berk. & Curt. N. Amer. Fung. n. 752, in Grevillea, vol. iv. (1875) p. 1; Sacc. Syll. viii. n. 1018.

On wood among mosses and hepatics, Tasmania (*Archer*). On dead wood among moss, Lower Carolina (*Ravenel*, n. 2977).

Approaching such species as *Helotium melleum* and *H. sublateritium*, but differing in the larger, 1-septate, and 1-seriate spores.

PEZIZA LEPIDA, *Berk. & Curt. in Proc. Amer. Acad.* vol. iv. (1858) p. 127; *Cooke, Mycogr.* p. 211, fig. 357. (Pl. XVI. fig. 11.)

Scattered, stipitate, substance thin, funnel-shaped, margin at first incurved, then erect; disc red, externally pale and rather scurfy, 5–8 mm. across; stem slender, 3–4 mm. long; substance entirely parenchymatous, cortical cells large, polygonal, running out in small groups to form the granular or scurfy exterior; asci cylindrical, apex rounded, not blue with iodine, 8-spored; spores obliquely 1-seriate, continuous, hyaline, smooth, elliptical, $14–15 \times 7\,\mu$; paraphyses slender, scarcely thickened at the tip.

Sarcoscypha lepida, Sacc. Syll. viii. n. 620.

On burnt earth. Japan (U.S. North Pac. Exped.; *Wright*, n. 149).

PEZIZA PUSIO, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 153.

Growing singly or 2–3 ascophores springing from a common

stem, urceolate or subglobose, mouth more or less contracted, disc concave, orange; externally glabrous, whitish, gradually passing into the elongated rooting stem, 3–4 mm. across, about 2 cm. high; ascophore homogeneous, consisting entirely of intricately interwoven, thick-walled hyphæ, about 4 μ thick; asci cylindrical, apex rounded, not blue with iodine, base narrowed into a pedicel, 8-spored; spores 1-seriate, hyaline, smooth, continuous, 15–16 × 7–8 μ, elliptic-oblong; paraphyses filiform, slender, septate, tips not thickened.

Sarcoscypha Pusio, Sacc. Syll. viii. n. 624.

Peziza (§ *Sarcoscypha*) *Pusio*, Cooke, Mycogr. p. 60, fig. 106.

Stamnaria Pusio, Massee, in Journ. Mycol. vol. vi. p. 179, pl. vii. figs. 16–18.

Rooting in the soil. Texas (*Wright*, n. 3145).

Horny and translucent when dry. Has all the characters of the genus *Stamnaria*.

PEZIZA COLENSOI, *Berk. in Hook. f. Fl. N. Zeal.* vol. ii. p. 200, tab. 5. fig. 5 (1855); *Cooke, Mycogr.* p. 61, fig. 108. (Pl. XVI. figs. 14, 15.)

Gregarious, stipitate; ascophore cup-shaped or funnel-shaped, margin incurved for some time, thin, rather tough, entirely pale tan-colour; disc concave, even and smooth, as is also the margin; externally very minutely pruinose and sometimes more or less wrinkled, about 1 cm. across; stem 0·5 cm. or more in length, often wrinkled, and sometimes slightly discoid at the base; hypothecium formed of densely compacted hyphæ, which run parallel to the surface of the disc, becoming much interlaced, and running in all directions in the excipulum or central portion, then again becoming parallel in a direction at right angles to that of the hypothecium, finally becoming parenchymatous at the cortex and running out in little groups of cells to form the external pubescence; asci cylindrical, apex rounded, not blue with iodine, narrowed below into a long pedicel, 320–350 × 15 μ, wall thick, 8-spored; spores obliquely 1-seriate, elliptic-fusiform, ends acute, continuous, hyaline, smooth, often 2–4-guttulate, 28–30 × 11–12 μ; paraphyses very slender, cylindrical, irregularly branched.

Sarcoscypha Colensoi, Sacc. Syll. viii. n. 633.

Peziza (§ *Geopyxis*) *aluticolor*, Berk. Austr. Fung. n. 220, in Journ. Linn. Soc. (Bot.) vol. xiii. (1873) p. 176; Cooke, Mycogr. p. 114, fig. 198.

Geopyxis aluticolor, Sacc. Syll. viii. n. 210.

On logs, branches, and twigs. New Zealand (*Colenso*, n. 2810; *Kirk*, n. 286); Brisbane (*Bailey*, n. 790); Clarence River, Australia; Inanda, Natal (*Wood*, n. 678); Cape of Good Hope (*MacOwan*, n. 1101); Fort Dauphin, Madagascar (*Scott Elliot*).

PEZIZA DOMINGENSIS, *Berk. in Ann. & Mag. Nat. Hist.* ser. II. vol. ix. (1852) p. 201; *Sacc. Syll.* viii. n. 359. (Pl. XVI. figs. 7, 8.)

Sessile, discoid, margin slightly upturned and often more or less wavy, rather fleshy, disc deep reddish-brown or chocolate-colour, very much cracked when dry; externally pale buff, wrinkled, at least when dry, 2–3 cm. across; consisting entirely of slender, interwoven hyphæ, central portion least compact; asci cylindrical, apex obtuse, not becoming blue with iodine, 8-spored, about $250 \times 14\ \mu$; spores 1-seriate, hyaline, smooth, continuous, broadly elliptical, ends obtuse, very slightly inæquilateral, often 2-guttulate, $24–26 \times 11–12\ \mu$; paraphyses very slender, not thickened at the tips.

Peziza crispata, Berk. & Curt. in Journ. Linn. Soc. (Bot.) vol. x. (1869) p. 367.

Lachnea crispata, Sacc. Syll. viii. n. 682.

Phillipsia kermesina, Kalchb. & Cooke, in Grevillea, vol. ix. (1880) p. 25; Sacc. Syll. viii. n. 606.

Helotium purpuratum, Kalchb. in Thuemen, Myc. Univ. n. 1614; also in Roum. Fung. Sel. Exs. n. 4634.

On rotten wood. St. Domingo (*Sallé*, nn. 42 & 83); Cuba (*Wright*, nn. 348, 660, 661, & 716); St. Thomas, W. Indies; Natal (*J. M. Wood*, n. 411); Cape of Good Hope (*MacOwan*, n. 1102).

The African specimens agree exactly in structure with the West-Indian type, but in the dry condition the disc is a little paler in colour. In one of the Cuban specimens the ascophore is continued downwards into a short, stout, stem-like base which is densely downy.

PEZIZA EPISPARTIA, *Berk. & Broome, in Journ. Linn. Soc.* (*Bot.*) vol. xvi. (1877) p. 103; *Cooke, Mycogr.* p. 171, fig. 296; *Sacc. Syll.* viii. n. 323.

Sessile and attached by a central point, soon expanding until plane, margin often lobed or waved, substance rather thin; disc

brownish with a tinge of flesh-colour, or sometimes tinged lilac, even; externally densely tomentose, hairs pale brown, septate, obtuse, 53–70 × 12 μ, 1·5–2·5 cm. across; excipulum and cortex formed of irregular, interwoven hyphæ, which run out into the external hairs; asci cylindrical, apex obtuse and not blue with iodine, 80–90 × 5 μ; spores 8, 1-seriate, hyaline, smooth, continuous, elliptical, ends obtuse, 7 × 3 μ; paraphyses slender, scarcely thickened at the tip.

On very rotten wood and on the ground, in which case it probably springs from decayed vegetable matter. Ceylon (*Thwaites*, nn. 71 & 1054); India (*Colonel Hobson*).

Remarkable for the very small asci and spores, also for the structure of the exterior of the ascophore, which is too decidedly tomentose for the genus *Peziza*.

PEZIZA KERGUELENSIS, *Berk. in Hook. f. Fl. Antarct.* p. 451, pl. 164. n. iii. figs. 1, 3, 4, 5 (1847); *Cooke, Mycogr.* p. 74, fig. 134.

Ascophore sessile, applanate, almost plane, the margin only free from the substratum and slightly raised, rather fleshy, 1–2 cm. broad; disc crimson, externally paler, and scantily furnished with thick-walled, septate, pointed, dark brown hairs, 50–100 × 8–10 μ; cortex parenchymatous, cells large; asci cylindrical, apex blunt, not blue with iodine; spores 8, 1-seriate, hyaline, smooth, continuous, broadly elliptical, ends obtuse, contents coarsely granular, 21–23 × 16–17 μ; paraphyses septate, slender, apex pyriform, 8–10 μ thick.

Lachnea kerguelensis, Sacc. Syll. viii. n. 710.

On bare boggy earth near the sea, growing amongst Confervæ. Kerguelen's Land, Christmas Harbour (*Dr. Hooker*); Betsy Cove and Royal Sound (*'Challenger' Exp.*); New Zealand (*Berggren*, n. 274; *Dr. Hooker*).

Distinguished amongst many close allies by the large ascophore, scanty and comparatively small external hairs, and the very broad, smooth spores.

PEZIZA SPRAGUEI, *Berk. & Curt. in herb. Cooke, fide Bull. Buff. Acad. Sc.* 1870, p. 289; *Cooke, Mycogr.* fig. 308. (Pl. XVIII. fig. 1.)

Sessile, broadly attached to the substratum by the downy rhizoids, extreme margin free, downy, slightly upraised (when dry at least); disc pale reddish-brown, 1·5–2·5 cm. across; hypo-

thecium, excipulum, and cortex composed entirely of interwoven hyphæ, which run out to form the external down; asci elongated and narrow, cylindrical; apex rounded, becoming deep blue with iodine, about $250 \times 9\,\mu$; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, elliptical, ends obtuse, $13–14 \times 7–8\,\mu$; paraphyses septate, very slightly thickened and coloured at the tips.

Neottiella Spraguei, Sacc. Syll. viii. n. 775.

On rotten wood. Maine, U.S.A. (*Sprague*, n. 5325). Other U. States localities are given by Cooke in 'Mycographia,' but Sprague's specimens are the only ones in the Kew herbarium.

The present species has all the characters of the genus *Rhizina*, and will in future stand as *Rhizina Spraguei*.

PEZIZA VINOSA-BRUNNEA, *Berk. & Broome, in Trans. Linn. Soc.* ser. II. *Bot.* vol. i. (1880) p. 404, pl. 45. figs. 11–13.

Gregarious or crowded, sessile but narrowed to a short stem-like base, subglobose and closed at first, then expanding, margin wavy, often irregular from mutual pressure, rather fleshy, every part of a clear reddish or purple-brown; externally sparsely clothed with long, slender, subcylindrical, septate, almost colourless hairs, which are sometimes in small fascicles, $150–200 \times 5–6\,\mu$, lower down the ascophore the hairs pass into straggling hyphæ which fix the fungus to the substratum; cortex parenchymatous; ascophore 4–10 mm. across; asci cylindrical, apex truncate, not blue with iodine, $250 \times 14–15\,\mu$; spores 8, obliquely 1-seriate, continuous, hyaline, smooth, elliptical, ends narrowed, $24–25 \times 11–12\,\mu$; paraphyses slender, septate, apex very slightly thickened, sometimes branched.

Lachnea vinosa-brunnea, Sacc. Syll. viii. n. 687.

On burnt ground. Brisbane (*Bailey*, n. 19).

PEZIZA GENEOSPORA, *Berk. in Hook. Journ. Bot.* vol. iii. (1851) p. 203; *Cooke, Mycogr.* p. 72, fig. 130. (Pl. XVII. fig. 30.)

Sessile but narrowed below to a central point of attachment, rather fleshy; disc slightly concave, clear crimson; externally paler and bristling with thick-walled, ventricose, pointed, septate, dark brown hairs, which are most abundant near the margin, where they measure $200–350 \times 14–20\,\mu$, base of hairs narrowed and sometimes branched, rarely more or less bulbous; ascophores 1·3 cm. across; cortex parenchymatous, cells large; asci cylin-

drical, apex rounded, not blue with iodine, narrowed below into a long pedicel; spores 8, obliquely 1-seriate, hyaline, continuous, at length coarsely warted, elliptical, ends pointed, sometimes slightly inæquilateral, $30 \times 12–15\ \mu$; paraphyses slender, septate, slightly thickened at the tip.

Lachnea geneospora, Sacc. Syll. viii. n. 720.

On rotten wood. Sinchul, India; 8000 ft. (*Dr. Hooker*).

A well-marked species, characterized by the large elliptic-fusiform, coarsely warted spores.

PEZIZA STYGIA, *Berk. & Curt. N. Amer. Fung.* n. 720, *in Grevillea*, vol. iii. (1875) p. 153; *Cooke, Mycogr.* p. 60, fig. 105.

Ascophore turbinate, closed at first, then expanding, rather fleshy, entirely black, disc with an olive tinge; externally somewhat hispid, due to the presence of brown, septate, blunt hyphæ which are flexuous and variously curled, $70–100 \times 6–8\ \mu$, 1–1·5 cm. across; stem more or less elongated, rooting, strigose; hypothecium and excipulum formed of thin, interwoven, hyaline hyphæ which pass into a brown-celled parenchymatous cortex from which the external hairs spring; asci cylindrical, apex rounded and not blue with iodine, wall thick, 8-spored; spore 1-seriate, hyaline, smooth, globose, wall thick, 11–12 μ diameter; paraphyses slender, slightly thickened and curved at the tip.

Pseudopeziza stygia, Sacc. Syll. viii. n. 667.

Damp ground among mosses. Lower Carolina, U.S.A. (*Ravenel*, n. 2971).

Very closely allied to *Peziza nigrella*, Pers., differing mainly in the smaller size of the ascophore. *Peziza melæna*, Fr., differs from both in being glabrous externally.

PEZIZA TRECHISPORA, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* vol. xviii. (1846) p. 77; *Cooke, Mycogr.* p. 72, fig. 129. (Pl. XVI. figs. 20, 21.)

Scattered, sessile, subglobose and closed at first, soon becoming quite plane and adpressed to the substratum, rather fleshy, ½–1 cm. across; disc varying from orange-red to crimson; externally paler, and clothed with stout, septate, thick-walled, acute, brown hairs, the marginal ones best developed, $200–350 \times 8–12\ \mu$, base of hairs often more or less swollen or branched; cortical cells large, polygonal; asci large, cylindrical, apex rounded, 8-spored; spores 1-seriate, globose, hyaline, wall thick, for a long

time smooth, then densely covered with cylindrical papillæ 2–3 μ long, 19–22 μ diameter; paraphyses stout, clavate, septate, apex containing red granules when fresh.

Lachnea trechispora, Phillips, Brit. Disc. p. 218, pl. 7. fig. 41.

Sphærospora trechispora, Sacc. Syll. viii. n. 763; Massee, Fungus-Flora, vol. iv. p. 293 (spore incorrectly described as reticulated).

Peziza asperior, Nyl., Pez. Fenn. p. 21 (1868); Cooke, Monogr. p. 30, fig. 51; Phillips, Brit. Disc. p. 85.

Sphærospora asperior, Sacc. Syll. viii. n. 764; Massee, Fungus-Flora, vol. iv. p. 293.

Exsicc. Phillips, Elv. Brit. n. 160; Roum. Fung. Sel. Exs. nn. 4164 & 4630; Rehm, Ascom. nn. 3 & 405; Thuemen, Myc. Univ. n. 1211; Vize, Micro-Fung. Brit. n. 367; Sacc. Myc. Ven. n. 1516; Cooke, Fung. Brit. Exs. n. 288; Rabenh. Fung. Eur. n. 26.

On the ground, often among moss, rarely on rotten wood. Britain, King's Cliffe, Northa. (*Berkeley*); France (*Quélet*); Germany (*Britzetmayr & Rehm*); Italy (*Saccardo*). Lapland and Finland (*Nylander*).

Nylander's fungus—*P. asperior*—is identical with the previously described *P. trechispora*, Berk. I stated in my 'Fungus-Flora,' vol. iv. p. 293, that *P. trechispora* was distinguished from *P. asperior* by having the epispore covered with a raised network, and not warted; this, however, proves to be a mistake, the epispore in *P. trechispora* being distinctly warted at maturity.

PEZIZA TURBINELLA, *Berk. Dec. Fung.* n. 358, *in Hook. Kew Journ. Bot.* vol. iii. (1851) p. 204. (Pl. XVIII. figs. 11, 12.)

Scattered or gregarious, turbinate, stipitate, glabrous, altogether $\frac{1}{2}$–$\frac{3}{4}$ mm. high, the ascophore gradually narrowing into the slender stem; disc gradually expanding until plane or slightly convex, white or with a tinge of yellow, horny and pellucid when dry; stem composed of parallel septate hyphæ which pass upwards and form the cortex; asci narrowly cylindric-clavate, apex slightly pointed, the pore of dehiscence blue with iodine, tapering below into a very slender pedicel, about 140 × 7 μ; spores needle-shaped, arranged in a parallel fascicle in the ascus, 70 × 1 μ; paraphyses numerous, very slender, apex not thickened except in those paraphyses nearest to the cortex, which are pyriform at the apex.

Vibrissea turbinella, Sacc. Syll. viii. n. 174.

Peziza stilboidea, Berk. Dec. Fung. n. 359, in Hook. Journ. Bot. vol. iii. (1851) p. 204.

Vibrissea stilboidea, Sacc. Syll. viii. n. 176.

On the under surface of leaves of *Pyrus* sp. Tonglo, Ind. Or. (*Dr.* [now *Sir*] *J. D. Hooker*).

PEZIZA JOHNSTONI, *Berk. in Ann. & Mag. Nat. Hist.* vol. xiii. (1844) p. 17.

This species is synonymous with *Peziza fusca,* Pers. Obs. i. p. 29 (1799).

PEZIZA ERIOBASIS, *Berk. in Ann. & Mag. Nat. Hist.* vol. xiii. (1844) p. 355. (Pl. XVIII. fig. 6.)

Solitary, or more frequently in scattered groups of 2–5 individuals densely crowded together; ascophores subglobose and closed at first, then plane or the extreme margin slightly raised, usually irregular in form from mutual pressure, $\frac{3}{4}$–$1\frac{1}{2}$ mm. across; disc white, becoming yellowish with age or when dry, outside white and downy, seated on a snow-white, delicate, radiating mycelium, formed of branched septate hyphæ about 4 μ thick; asci clavate, apex slightly narrowed; spores 8, 2-seriate, elliptic-oblong, hyaline, continuous, $5–6 \times 1{\cdot}5\ \mu$; paraphyses very slender, cylindrical.

On the inside of bark. Sherwood Forest, Notts (*Berkeley*).

Tapesia eriobasis, Phillips, Brit. Disc. p. 278; Sacc. Syll. viii. n. 1582; Massee, Fungus-Flora, vol. iv. p. 300.

Differs from other species of *Tapesia* in the groups of ascophores being more distant from each other than is usual in the genus. Each group is surrounded by its own snow-white radiating hyphæ; and unless the groups happen to be near to each other, the mycelium does not coalesce to form a continuous subiculum. Resembling *Peziza candidata,* Cooke in Grevillea, vol. i. (1872) p. 130, in habit.

PEZIZA MUTABILIS, *Berk. & Broome, in Ann. & Mag. Nat. Hist* ser. II. vol. vii. (1851) p. 14. (Pl. XVIII. fig. 7.)

Scattered or gregarious, appearing as minute, dark-brown downy points; ascophore at first subglobose and closed, gradually expanding until quite plane, about $\frac{1}{2}$ mm. across; disc whitish, externally brown and glabrous; cortex parenchymatous, cells subcircular or obtusely hexagonal, brownish, 7–10 μ diameter, running out into narrow, elongated, parallel cells at the very

blunt margin; asci narrowly clavate, apex narrowed; spores 8, irregularly 2-seriate, hyaline, narrowly cylindric-fusiform, sometimes 2-guttulate, $14–17 \times 2{\cdot}5–3\ \mu$; paraphyses very slender, cylindrical, hyaline.

Tapesia mutabilis, Phillips, Brit. Disc. p. 278; Sacc. Syll. viii. n. 1553.

Mollisia mutabilis, Massee, Fungus-Flora, vol. iv. p. 496.

On dead leaves of *Aira cæspitosa* and other grasses. Derry Hill, Wilts.

A typical *Mollisia*, and not a *Tapesia*, as clearly pointed out by Berkeley in a paragraph following his description of the species, which is as follows:—"We have not placed this curious species amongst the *Tapesiæ*, as the cups are essentially solitary. When old it bears some resemblance to pale forms of *P. atrata* or *P. palustris*."

PEZIZA SORDESCENS, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 150; *Cooke, Mycogr.* fig. 191.

Ascophore stipitate, subglobose, and the margin incurved at first, then expanding until almost plane, often slightly lobed or irregular in outline, rather fleshy, very rigid when dry; disc bright brown, even, or slightly nodulose towards the base; externally minutely granulato-pubescent, at first golden yellow, becoming dark with age; 3–4 cm. across; stem about 2 cm. long, stout, cylindrical, pubescent and yellowish, springing from a spreading mycelium; hypothecium and excipulum formed of hyaline, septate, irregularly inflated, interwoven hyphæ, which pass into a coloured pseudoparenchymatous cortex, the cells of which run out in groups to form the granular exterior of the ascophore; asci cylindrical, apex obtuse and not blue with iodine, about $160 \times 10\ \mu$; spores 8, 1-seriate, hyaline, continuous, smooth, elliptical, often 2–3-guttulate, $14–15 \times 7\ \mu$; paraphyses slender, septate, coloured at the slightly clavate tips.

On soil, over which a thin mycelium spreads and binds the particles. New England, United States (*Murray*, n. 5327).

PEZIZA DRUMMONDI, *Berk. in Hook. Lond. Journ. Bot.* vol. iv. (1845) p. 71, tab. 2. fig. 10; *Cooke, Mycogr.* fig. 219; *Sacc. Syll.* viii. n. 279.

Scattered or gregarious, sessile, globose and closed at first, then opening, but the aperture remaining small, externally furfuraceous or slightly warted and traversed by contorted ribs,

which run down to the base of the ascophore and into the ground, brown; disc brighter in colour, concave, up to 1 cm. across, flexible and cartilaginous when moist, rigid when dry; hypothecium and excipulum formed of interwoven, hyaline, septate much-branched hyphæ, the first mentioned densest, and passing into a brown parenchymatous cortex, many of the cells projecting in clusters to form the rough exterior; asci cylindrical, apex truncate, not blue with iodine, about 300 × 12 μ; spores 8, elliptical, ends obtuse, hyaline, smooth, continuous, 15–16 × 8 μ, obliquely 1-seriate; paraphyses slender, tips slightly thickened and brownish.

On the ground. Swan River, Australia (*Drummond*, n. 183); near Melbourne, Australia (*Reader*).

Cooke's figures quoted above are not good, the ascophore is much more expanded than in the type specimens.

Peziza chrysotricha, *Berk. in Hook. f. Fl. Nov. Zeland.* vol. ii. p. 201 (1856); *Handb. N. Zeal. Flora*, p. 629.

Gregarious, sessile, erumpent, globose and closed at first, then expanding until saucer-shaped, closed by the infolding of opposite sides when dry, 2–3 mm. across, entirely deep orange-yellow; disc even; externally minutely woolly, due to the presence of cylindrical, septate, wavy, interlaced hairs, which are sometimes rough with minute particles of oxalate of lime, 50–60 × 4 μ; hypothecium, excipulum, and cortex formed of slender, densely interwoven, septate hyphæ, which pass out to form the external hairs; asci cylindric-clavate, apex obtuse, not blue with iodine, pedicel stout, 90–100 × 11–12 μ; spores irregularly 2-seriate, continuous, hyaline, smooth, narrowly elliptic-fusiform, ends acute, slightly inæquilateral or bent, 19–20 × 5 μ; paraphyses very slender, cylindrical, tips not at all thickened.

Trichopeziza chrysotricha, Sacc. Syll. viii. n. 1696.

On dead twigs. Waikare Lake, N. Island, New Zealand (*Colenso*).

Readily distinguished by the deep orange colour of every part and the fusiform narrow spores.

Peziza macrotis, *Berk. in Hook. Kew Journ. Bot.* vol. iii. (1851) p. 203. (Pl. XVII. fig. 31.)

Ascophores gregarious (5–50), forming the terminations to the branches of a stout stem-like base, subspathulate or hare's-ear-shaped, 3-8 cm. long, 1-2·5 cm. broad, edges more or less involute,

dry and leathery, somewhat cartilaginous when dry, everywhere glabrous, liver-colour; disc with a tinge of purple, much cracked when dry, the entire fungus sometimes paler; stem-like base corky, stout, short or elongated, 2–8 × 1–2 cm.; hypothecium of brown, closely interwoven hyphæ; in the excipulum the hyphæ are colourless and not so densely interlaced, again becoming brown and closely compacted in the cortex; asci cylindrical, apex rounded, about 200 × 15 μ; spores 8, 1-seriate, hyaline, smooth, continuous, elliptical, often slightly inæquilateral, 1–3-guttulate, 24–28 × 11–13 μ; paraphyses slender, septate, tips slightly clavate.

Midotis macrotis, Sacc. Syll. viii. n. 2256.

Wynnea macrotis, Berk. in Journ. Linn. Soc. (Bot.) vol. ix. (1865) p. 424; Cooke, Mycogr. fig. 94.

Wynnea gigantea, Berk. *l. c.* t. 12; Cooke, *l. c.* fig. 93.

Midotis gigantea, Sacc. Syll. viii. n. 2255.

On rotten wood, about stumps, &c. Darjeeling, 7500 ft., Sikkim (*Dr. Hooker*, n. 87, with fig.); Brazil (*Glaziou*, n. 20181); Solomon Is. (*Dr. Guppy*); Mexico (*Sallé*, nn. 30, 178); also collected in Mexico by Señor Botteri.

Numerous specimens of both Berkeley's species prove that his *Wynnea gigantea* is identical with *Peziza macrotis*. Somewhat variable in form, sometimes only a few very large hare's-ear-shaped ascophores spring from a stout, short, common base; in other specimens the base is elongated and branched, the branchlets bearing in some instances scores of comparatively small, often spoon-shaped, and sometimes proliferous ascophores.

PEZIZA IRRORATA, *Berk. & Curt. in Grevillea*, vol. iii. (1875) p. 150; *Cooke, Mycogr.* p. 150, fig. 254; *Sacc. Syll.* viii. n. 302.

Sessile and attached by a broad base, then expanding until almost plane; substance rather thin, entirely dingy grey with a tinge of tan (when dry), externally slightly furfuraceous or almost smooth, about 2·5 cm. across; excipulum formed of interwoven hyphæ, passing into a pseudoparenchymatous cortex; asci cylindrical, apex rounded, about 300 × 12–13 μ, not blue with iodine, but the hymenial gelatine becoming blue; spores 8, obliquely 1-seriate, hyaline, continuous, broadly elliptical, ends obtuse, thickly studded with small hemispherical warts, 15–18 × 10–12 μ; paraphyses rather stout, septate, tips clavate or pyriform.

On the ground. Texas (*Wright*, n. 3138).

PEZIZA PETERSII, *Berk. & Curt. in Grevillea*, iii. (1875) p. 150; *Cooke, Mycogr.* p. 146, fig. 246; *Sacc. Syll.* viii. n. 281.

Sessile, at first with the margin incurved and closed, finally becoming nearly plane, usually waved and irregular, rather fleshy; disc reddish brown, externally pallid and minutely furfuraceous, 2–5 cm. across; ascophore formed of interwoven hyphæ; asci cylindrical, apex obtuse, only very slightly narrowed downwards, about $200 \times 10\ \mu$; spores 8, elliptic-oblong, ends obtuse, continuous, hyaline, for a long time smooth, then exceedingly minutely asperate, usually 2-guttulate, $10\text{–}12 \times 5\text{–}6\ \mu$; paraphyses slender, expanding into a stout clavate or pyriform coloured apex.

On burnt soil. Alabama (*Peters*, n. 6063).

The minute raised points on the epispore are very minute, and barely visible under a magnification of 400 diameters. Remarkable for the small size of the spores and the much swollen tips of the paraphyses. Cooke's figure, quoted above, is incorrect, the paraphyses being cylindrical and not at all thickened at the apex.

PATELLARIA ATRO-FUSCA, *Berk. & Curt. in Grevillea*, vol. iv. (1875) p. 2.

Gregarious; orbicular, margin slightly raised, substance rather thick, glabrous, blackish brown, $\frac{1}{3}\text{–}\frac{1}{2}$ mm. diameter; hypothecium and excipulum formed of slender interwoven hyaline hyphæ, which become arranged in a parallel manner in the cortex and margin of the ascophore and run out into the thickened brown grumous tips to form the exterior; asci clavate, apex rounded, wall thickened, and pore of dehiscence deep-blue with iodine, often slightly curved, $80\text{–}90 \times 10\ \mu$; spores 8, obliquely 1-seriate below, 2-seriate at the apex of the ascus, hyaline, narrowly elliptic-fusiform, straight or slightly curved, finally 3-septate, smooth, $16\text{–}20 \times 3\text{–}4\ \mu$; paraphyses numerous, septate, very slender, not at all thickened at the tips.

Lecanidion atro-fuscum, Sacc. Syll. viii. n. 3281.

On small twigs of *Vitis vulpina*. Lower Carolina (*Ravenel*, n. 2210).

Berkeley says, "springing from a black thin stratum which surrounds the twigs"; this stratum is not obvious at the present time. In the original description the collector's number is stated to be "3210"; this is a slip, the number "2210" being on the ticket. No. 5958, alluded to by Berkeley as probably being a young state of the present species, I cannot find.

PEZIZA PHLEBOPHORA, *Berk. & Curt. in Ann. & Mag. Nat. Hist.* ser. III. vol. xviii. (1866) p. 8, pl. 3. figs. 9–11; *Cooke, Mycogr.* p. 126, fig. 217.

Sessile, but narrowed into a very short stem-like base, becoming rather widely expanded and shallowly cup-shaped, usually somewhat oblique, 1·5–2 cm. across, entirely of a yellowish-brown colour, substance rather thin; hypothecium and excipulum composed of intricately interwoven hyphæ, which pass into a cortical layer of polygonal pale brown cells, 8–12 μ diameter; externally ornamented with branched ribs or veins, which extend from the base of the ascophore and often end in little pits; disc often more or less veined; asci narrowly cylindrical, apex obtuse, not blue with iodine; spores 8, obliquely 1-seriate, elliptic-oblong, continuous, smooth, hyaline, often 2-guttulate, $10–12 \times 5–6 \mu$; paraphyses rather stout, septate, apex clavate, 5–6 μ thick, straight or slightly bent.

Otidea phlebophora, Phillips, Brit. Disc. p. 55; Sacc. Syll. viii. n. 362; Massee, Fungus-Flora, vol. iv. p. 445.

On dry banks, usually growing singly. King's Cliffe (*Berkeley*).

So far as I can ascertain, this species has not been collected out of England. There is a specimen under this name in the Berkeley Herbarium, Kew, collected in Alabama by Peters, n. 4560, and another from Melbourne collected by Mrs. Martin, n. 479; but neither of these belong to the present species, and, furthermore, do not agree with any described species.

PEZIZA DARJEELENSIS, *Berk. in Hook. Kew Journ. Bot.* vol. iii. (1851) p. 202.

Peziza (§ *Cochleatæ*) *darjeelensis*, Cooke, Mycogr. p. 125, fig. 215.

Ascophore sessile, closed at first, then expanding, more or less cochleate or contorted and split down one side, rather fleshy; disc umber-brown, externally paler and minutely pulverulent, 4–7 cm. across; hypothecium, excipulum, and cortex parenchymatous, cells very large and polygonal in the cortex; asci cylindrical, apex rounded, not blue with iodine, measuring about $260 \times 10 \mu$; spores obliquely 1-seriate, hyaline, continuous, minutely warted, elliptical, ends obtuse, $14–15 \times 8 \mu$; paraphyses slender, tips brownish and slightly clavate.

Otidea darjeelensis, Sacc. Syll. Suppl. x. n. 4473.

On the ground. Darjeeling, India (*Dr. Hooker*); Melbourne, Australia (*Reader*, n. 19).

Closely allied to *Otidea alutacea*, Massee, but distinguished

more especially by the much larger, polygonal cells of the parenchymatous ascophore.

Peziza Eucalypti, *Berk. in Hook. f. Fl. Tasm.* vol. ii. p. 274, t. 183. fig. 13 (1860). (Pl. XVI. fig. 23.)

Gregarious, stipitate; ascophore ½–1 mm. across, rather fleshy, at first closed, then expanding until nearly or quite plane; pale olive or tan, with a purple tinge; clothed externally with long bristle-like spines of a purple-brown colour, formed of a fascicle of septate hyphæ; spines most abundant and longest at the margin, falling away with age and leaving the ascophore bald; stem stout, 1–1·5 mm. long, often curved, ornamented at an early stage with scattered short spines; cortex parenchymatous, cells large; asci cylindric-clavate, apex slightly narrowed; spores 8, obliquely 1-seriate, or inclined to become 2-seriate, hyaline, smooth, continuous, narrowly elliptic-oblong, often slightly curved, $9–11 \times 3\ \mu$; paraphyses slender, slightly thickened upwards.

Dasyscypha Eucalypti, Sacc. Syll. viii. n. 1924.

On dead leaves of *Eucalyptus*. Tasmania (*Archer*). On phyllodes of *Acacia longifolia* and on *Casaurina*: Victoria (*Mrs. Martin*).

A very minute, but beautiful species. Should be placed in the genus *Cyathicula*, characterized by the spines or teeth of the margin consisting of a fascicle of hyphæ.

Peziza monilifera, *Berk. & Curt. Cuban Fungi*, n. 673, *in Journ. Linn. Soc.* (*Bot.*) vol. x. (1869) p. 367; *Cooke, Mycogr.* p. 86, fig. 158. (Pl. XVI. fig. 22.)

Hemispherical and umbilicate at first, gradually expanding until plane or slightly convex, margin often wavy, disc yellow, 2–4 mm. across; externally and the margin minutely pubescent, hairs very delicate, septate, colourless, tapering towards the apex, $50–80 \times 5–6\ \mu$; excipulum parenchymatous, cortical cells large; asci cylindrical, apex rounded, not blue with iodine, wall thick; spores 8, 1-seriate, globose, hyaline, smooth, 15–16 μ diameter; paraphyses slender, apex clavate.

Pyronemella monilifera, Sacc. Syll. n. 794.

On the ground. Cuba (*Wright*, n. 375); Lower Carolina (*Ravenel*, n. 3802).

Resembling *Peziza gemmea*, Phillips, *P. Archeri*, Berk., and *P. globifera*, Berk. & Curt., in the small, hyaline, smooth, globose spores, but distinguished from all by the pilose exterior of the ascophore.

Peziza puberula, *Berk. & Curt. N. Amer. Fung.* n. 729, *in Grevillea*, vol. iii. (1875) p. 155. (Pl. XVI. figs. 24, 25.)

Gregarious, very minute, sessile, but narrowed below into a central point of attachment, entirely pallid or buff (when dry); globose and closed at first, gradually expanding until quite plane; externally and the margin tomentose; hairs longest and most abundant at the margin, where they form a fringe, cylindrical, apex obtuse or slightly thickened, septate, minutely rough with particles of lime, almost hyaline, $60–80 \times 5–6\ \mu$; asci narrowly clavate, apex not blue with iodine, 8-spored; spores irregularly 2-seriate, cylindric-filiform, usually slightly curved, hyaline, continuous, smooth, $3–4 \times 1\ \mu$; paraphyses lanceolate, apex pointed, longer than the asci.

Dasyscypha puberula, Sacc. Syll. viii. n. 1921.

On pallid spots on fallen leaves of *Fraxinus*. Lower Carolina (*Ravenel*).

Peziza ilicincola, *Berk. & Broome, in Ann. & Mag. Nat. Hist.* ser. III. vol. vii. (1861) p. 449, pl. 16. fig. 17. (Pl. XVIII. figs. 15–18.)

Cæspitose, gregarious or scattered, urceolate or subglobose and closed at first, then expanding, margin often wavy, persistently incurved, often irregular when crowded, 1–2·5 mm. diameter; disc greyish or often rufescent with age; externally, especially at or near the margin, whitish and minutely downy or hoary, due to the presence of numerous hyaline, continuous, spine-like hyphæ, slight, tapering to the hooked tip, $18–20 \times 3–5\ \mu$; these hairs are outgrowths of the brown cortical cells; asci very numerous, cylindrical, apex slightly narrowed, not blue with iodine, pedicel slender, often crooked, about $50–55 \times 5–6\ \mu$; spores 1-seriate, hyaline, smooth, globose, 1-guttulate, 3·5–4 μ diameter; paraphyses slender, septate, cylindrical or sometimes very slightly thickened upwards.

Mollisia (§ *Mollisiella*) *ilicincola*, Phillips, Brit. Disc. p. 193.

Pseudohelotium (§ *Mollisiella*) *ilicincolum*, Sacc. Syll. viii. n. 1267.

Mollisiella ilicincola, Massee, Fungus-Flora, iv. 222, with fig.

Peziza (§ *Encœlia*) *Ravenelii*, Berk. & Curt. in Grevillea, vol. iii. (1875) p. 152.

Cenangium Ravenelii, Sacc. Syll. viii. n. 2346.

Peziza hysterigena, Berk. & Broome, in Journ. Linn. Soc. (Bot.) xiv. (1873) p. 106.

Lachnellula hysterigena, Sacc. Syll. viii. n. 1613.

Exsicc. Rav. Fung. Carol. Exs. n. 46.

Parasitic on the disc of *Blitrydium nigro-cinnabarinum* and on a species of *Myriangium*; also on the branches on which the host grows.

Chislehurst, England (*Currey*); Italy (*Cesati*); Mt. Macedon, Victoria (*Mrs. Martin*, n. 460); Central Province, Ceylon (*Thwaites*, n. 1067); S. Carolina (*Ravenel*, nn. 551, 1778, 2346, 3292).

There is ample material of the three supposed species given as synonymous above, which do not differ in the slightest detail. The figure of a section of the ascophore given in my 'Fungus-Flora,' vol. iv. p. 222, is not quite correct, the hypothecium and excipulum being too distinctly parenchymatous. The species is well characterized by the small globose spores and by the slender hyaline spine-like hairs, curved at the tip and springing from the marginal cortical cells. I consider the fungus as belonging to the genus *Mollisiella* rather than to *Lachnellula*, and in future it will be known as *Mollisiella ilicincola*.

EXPLANATION OF THE PLATES.

Plate XVI.

Fig. 1. *Gyromitra tasmanica*; spore, × 400.
2. *Helvella guepinoides*; spores, × 400.
3. *Mitrula vinosa*; ascus containing spores; × 400.
4. *Phillipsia Venezuelæ*, Berk. & Curt. Section through the entire fungus. *a*, ascus; *b*, paraphysis; *c*, hypothecium; *d*, excipulum; *e*, cortex. × 200.
5. Spores of same, × 400.
6. *Peziza emarginata*, Berk. & Broome. Spore, × 400.
7. *Peziza domingensis*, Berk.; plant, nat. size.
8. Spores of same, × 400.
9. *Phillipsia subpurpurea*, Berk. & Broome; section through ascophore, nat. size.
10. *Psilopezia flavida*, Berk. & Curt.; ascus and spores, × 400.
11. *Peziza lepida*, Berk. & Curt.; plant, nat size.
12. *Peziza radiculosa*, Berk. & Broome; section through portion of ascophore, × 400.
13. *Psilopezia nummularia*, Berk.; plants, nat size.
14. *Peziza Colensoi*, Berk.; section through ascophore, × 300.
15. Ascus (containing spores) and paraphysis, × 400.
16. *Peziza alphitodes*, Berk.; group of plants, nat. size.

PLATE XVI. (*continued*).

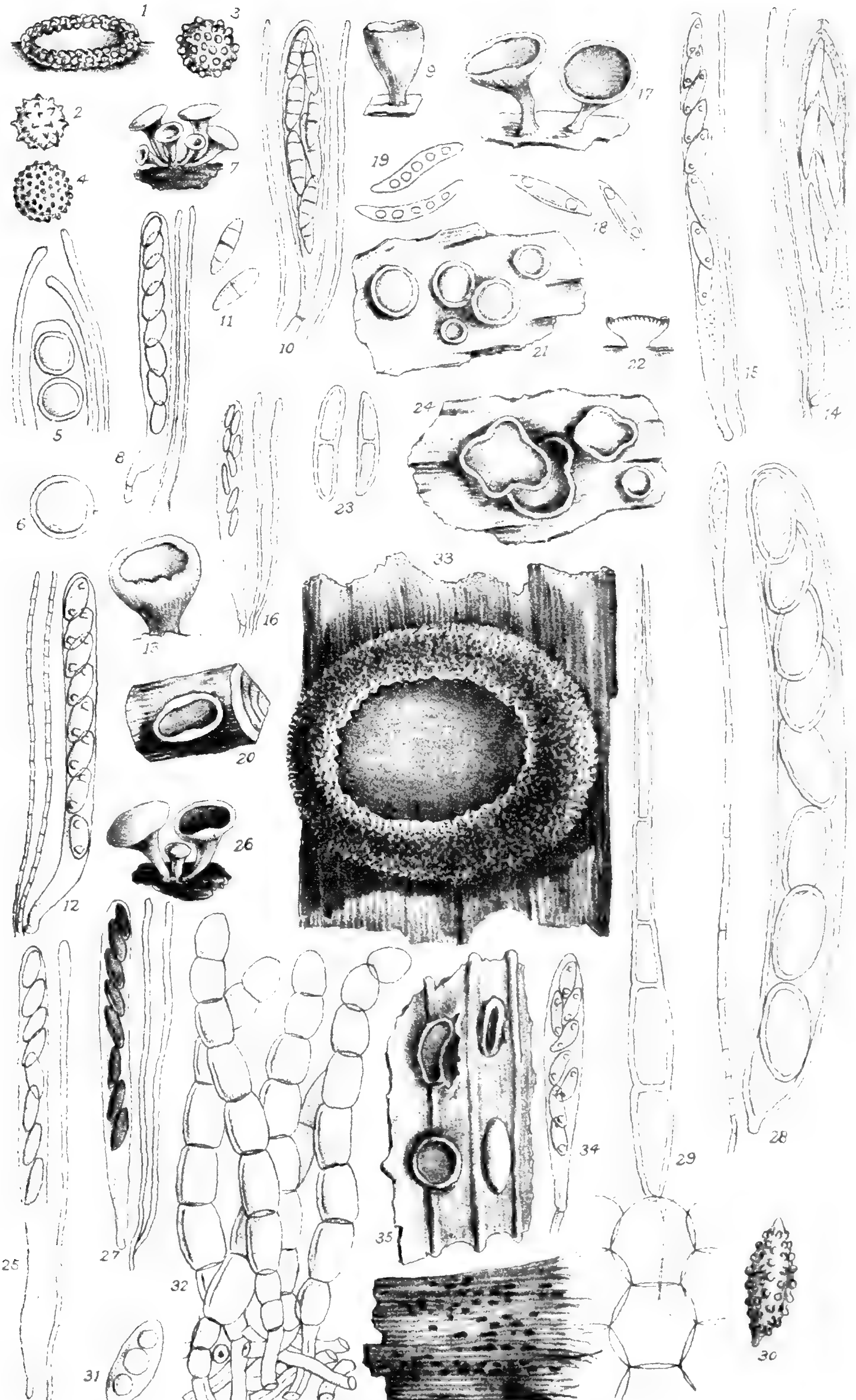
Fig. 17. *Peziza rhytidia*, Berk.; ascophore, nat size.
18. Spore of same, × 400. The spores are sometimes more pointed at the ends.
19. *Peziza semitosta*, Berk. & Curt.; section through cortex bearing external hairs, × 300.
20. *Peziza trechispora*, Berk.; section through fungus, nat. size.
21. Spore of same, × 400.
22. *Peziza monilifera*, Berk. & Curt.; spore, × 400.
23. *Peziza Eucalypti*, Berk.; plants, × 25.
24. *Peziza puberula*, Berk. & Curt.; asci and paraphysis, × 400.
Margin-hairs from ascophore of same, × 400.
26. *Peziza insititia*, Berk. & Curt. Two plants in different stages of growth: *a*, young and covered with scales externally; *b*, older plant, having the marginal scales alone remaining, nat. size.
27. Spore of same, × 400.
28. *Peziza atro-fusca*, Berk. & Curt.; two plants, × 10.
29. *Peziza scariosa*, Berk. & Curt.; groups of fungi seated on a dense subiculum, × 3.

PLATE XVII.

Fig. 1. Ascophore of *Peziza exasperata*, Berk. & Curt., nat. size.
2. Spore of same, × 400.
3. Spore of *Peziza recurva*, Berk., × 400.
4. Spore of *Peziza Wrightii*, Berk. & Curt., × 400.
5. *Peziza globifera*, Berk. & Curt.; apex of ascus containing two spores, also tips of paraphyses, × 400.
6. *Peziza sphæroplea*; spore, × 400.
7. *Helotium fasciculare*, Berk. & Broome; cluster of plants, × 3.
8. Ascus and paraphyses of same, × 400.
9. *Helotium miserum*, Berk. & Curt. s ngle plant, × 8.
10. Ascus and paraphyses of same, × 400.
11. Free spores of same, × 400.
12. *Helotium rhytidodes*, Berk. & Curt.; an ascus and paraphyses, × 400.
13. A single plant of same, × 8.
14. *Peziza crocata*; ascus and paraphyses, × 400.
15. *Peziza grata*; ascus and paraphyses, × 400.
16. *Helotium lentum*; ascus and paraphyses, × 400.
17. *Helotium sublateritium*, Berk. & Broome; two plants, × 6.
18. Two spores of same, × 400.
19. *Helotium melleum*; spores, × 400.
20. *Helotium rhytidodes*; single plant, seen from above, × 400.
21. *Helotium monticolum*; plant, × 6.
22. Section of same, × 6.
23. *Peziza pateræformis*; spores, × 400.
24. *Helotium alutaceum*; group of plants, × 8.
25. *Helotium Marchantiæ*; ascus and paraphyses, × 400.

G. Massee del. J. N. Fitch lith. & imp.

TYPES OF FUNGI.



G Massee del. J.N Fitch, lith & imp

TYPES OF FUNGI

G. Massee del. J. N. Fitch, lith & imp.

TYPES OF FUNGI

PLATE XVII. (*continued*).

Fig. 26. *Helotium agaricicolum*; plants, × 8.
27. Ascus and paraphyses of same, × 400.
28. *Peziza coprogena*, Berk. & Broome; ascus and paraphysis, × 400.
29. External hair and cortical cells of same, × 400.
30. *Peziza geneospora*, Berk.; spore, × 400.
31. *Peziza macrotis*, Berk.; spore, × 400.
32. *Peziza verruculosa*, Berk. & Curt.; portion of cortex, showing origin of the external hairs coating the outside of the ascophore, × 400.
33. *Rhizina spongiosa*, Berk. & Curt.; a medium-sized plant, nat. size.

PLATE XVIII.

Fig. 1. *Peziza Spraguei*, Berk. & Curt.; ascus and paraphysis, × 400.
2. *Peziza cubensis*, Berk. & Curt.; apex of ascus with spores and paraphysis, × 400.
3. *Cordierites coralloides*, Berk. & Curt., × 3.
4. *Cordierites Sprucei*, Berk.; plant, × 3.
5. Ascus and paraphyses of same, × 400.
6. *Peziza eriobasis*, Berk.; group of plants, × 6.
7. *Peziza mutabilis*, Berk. & Broome; plant on portion of a grass leaf, × 10.
8. *Peziza Harmoge*, Berk. & Broome; plant, nat. size.
9. Ascus and paraphysis of same, × 350.
10. *Rhizina zonata*, Berk.; spore, × 400.
11. *Peziza turbinella*, Berk.; plant, × 25.
12. Ascus and paraphyses of same, × 400.
13. *Patellaria proxima*, Berk. & Broome, nat. size.
14. Ascus and paraphyses of same, × 400.
15. *Peziza ilicincola*, Berk. & Broome, nat. size.
16. The same, showing the Peziza springing from the hymenium of *Blitrydium nigro-cinnabarinum*, slightly magnified.
17. Ascus, paraphyses, and spores of same, × 400.
18. Section through portion of ascophore of same, showing the external cortical cells bearing slender spine-like projections, × 400.
19. *Peziza russa*, Berk. & Broome; ascus and paraphyses, × 400.
20. *Peziza ustalis*, Berk. & Curt.; portion of a group of plants, slightly magnified.
21. Ascus and spores of same, × 400.
22. *Peziza epitricha*, Berk.; ascus and paraphyses, × 400.
23. *Bulgaria decolorans*, Berk. & Curt.; plants, nat. size.
24. Ascus and spores of same, × 400.
25. *Peziza brassiæcola*, Berk.; ascus and paraphysis, × 400.
26. *Peziza atro-citrina*, Berk. & Broome; plant, × 25.
27. Ascus and spores of same, × 400.
28. *Peziza Taxodii*, Berk.; plants, nat. size.
29. Spores of same, × 400.
30. Plants of same, slightly magnified.

Relation of the Growth of Foliage-Leaves and the Chlorophyll Function.

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[Read 18th June, 1896.]

(PLATE XIX.)

Historical and General.—Investigation of the relation of the growth of leaves and their food-forming activity began with the work of De Saussure in 1804 (8), and since that time various phases of the subject have received an almost constant attention. However, it will be unnecessary to recount here the titles of the accumulated mass of literature, since all of the more important papers have been cited by Jost in a recent work to which frequent reference will be made (5). Broadly stated, the main purpose of the investigations described below may be said to be the determination of the extent to which leaves are dependent upon food-supplies constructed within their own tissues, and to what extent development may proceed at the expense of food stored in neighbouring or organically connected members, and also to ascertain if these relations may be modified. Incidentally, attention has been paid to the causes operative in producing deterioration in certain leaves when grown under such conditions that food-formation could not be carried on.

The result of such an enquiry, while of chief importance in the consideration of the characteristic physiological processes of the leaf, should be of value in the interpretation of certain correlation phenomena, and also be of assistance in the delimitation of the principles governing leaf-expansion.

A clear comprehension of the status of the subject may be gained by a brief consideration of the recent papers of Vines (9), Vöchting (10), and Jost (4 & 5) Vines's investigations were concerned with the relation of growth to assimilation; and from a series of experiments with plants in blue light, in an air free from CO_2, in darkness, and without iron, he concludes that it is possible for leaves to grow when not assimilating, and that the retarding effect of light is exhibited by leaves not assimilating. Since the results of the growth of plants in an atmosphere free from CO_2 in the hands of different workers are so much at variance, it is important to note that in such experiments Vines used seedlings

of *Cucurbita Pepo*, *Ricinus communis*, *Zea Mays*, and *Phaseolus multiflorus*, and tips of branches of adult specimens of *Cardiospermum Halicacabum*, *Dolichodeira tubiflora*, and *Helianthus annuus*. The seedlings were placed partly or entirely in the apparatus necessary to exclude CO_2, and the tips of the branches were securely sealed-in while attached to the plant. All the plants named were found capable of carrying on growth and development of the leaves, under the conditions named, during periods of from 6 to 8 days. No distinct statement was made as to how nearly the leaves attained a normal or adult size, but in some of the plants named a much longer period is necessary. This point has received especial attention from Vöchting. By a series of tests with tips of shoots and branches of *Mimosa pudica*, *Solanum tuberosum*, *Tropæolum Lobbianum*, and *Cardiospermum Halicacabum*, he found that none of these plants were able to form perfect leaves in an air free from CO_2. In some instances forms not widely divergent from the normal were attained, and these began to show signs of deterioration if the experiment were prolonged to cover from 14 to 18 days. The contradictory results of Vines and Vöchting are doubtless to be attributed to the difference in the duration of the experiments in each instance. Vöchting found that the development of a leaf from the rudimentary condition to the unfolding of the lamina proceeds in a normal manner in an atmosphere free from CO_2, and is therefore at the expense of food stored in the axis or seed. Batalin (1) had previously concluded that the development of a seedling is at the cost of the stored food in the seed until the supply is exhausted; but Vöchting found that when the unfolding of the laminæ began, both in the seedling and in shoots, abnormal features appeared and deterioration soon set in. For example, such an occurrence was noted in *Solanum*, although the tubers several centimetres distant were richly loaded with starch. Vöchting accounts for such results by the supposition that the conducting tissues in the later stages of development of the leaf are adapted for the conveyance of food-material, downward and away from the lamina, and that movement in the opposite direction is effected with difficulty; and since a limited growth may be accomplished with the small amount thus conveyed to the lamina, but deterioration soon occurs, he concludes that the growth and normal continuance of leaves is in some manner connected with the assimilation processes.

Later, F. Rosen (7) made a special examination of the conducting tissues, but was unable to find any conditions which facilitate the movement of plastic material in one direction and not in another.

Recently, L. Jost (5) has taken up the question as to the relation of growth and assimilation, and has also devoted some attention to the cause of deterioration of leaves grown in an air free from CO_2. In his experiments, *Mimosa pudica* was grown in an air free from CO_2, and with shoots of *Phaseolus multiflorus*, *Acacia lophantha*, *Oxalis Deppei*, and *O. lasiandra* in darkness. The greater part of his work is devoted to the behaviour of etiolated plants, and he was able to obtain etiolated leaves of normal stature on all the above plants, except *Oxalis*, by the removal of concurrent buds. Such tests were not made in an air free from CO_2 however. Since etiolation is due to the absence of the rays of light, from which the energy of chlorophyll action is derived, he claims that "Dunkelstarr" is due simply to the fact that the chloroplasts, in the absence of the conditions for their functional activity, form substances harmful to the organism—a fact to which he attributed the death of leaves in darkness, as well as in an air free from CO_2. In opposition to Vöchting, he concludes that growth is in no direct manner connected with assimilation.

So far as experimental tests have been made, leaves exhibit wide divergences of reaction in an air free from CO_2, as well as in darkness; and the writer has deemed it of the greatest importance, as a necessary preliminary to the elucidation of the main thesis, that the conditions upon which these variations depend should be accounted for. A comparison of the reactions of the species used by myself and others, in an air free from CO_2 and in darkness, has also been made.

Results of Experiments.

It would not be profitable to reproduce the pages of my note-books descriptive of the separate experiments, and only the general results of each of the series of tests are given under the name of the species concerned.

The following species have been used in my work, viz., *Arisæma triphyllum*, *Calla palustris*, *Hibiscus Rosa-sinensis*, *Isopyrum biternatum*, *Justicia* sp., *Lilium tigrinum*, *Oxalis*

floribunda and *O. vespertilionis*, *Phœnix dactylifera*, *Trillium erectum*, *T. erythrocarpum*, and *Zea Mays*.

Arisæma triphyllum, Schott.

The form and habit of this species are such that it lends itself very readily to the necessary series of experiments. On this account a much wider range of tests were made with it than with any of the other plants mentioned, and altogether it formed the subject of 46 experiments. The large tuberous corms were gathered from the soil in woods in October, and placed in a cold house until February 1st, when they were placed in a temperate room, beginning growth two weeks later. Ordinarily the plant sends up one or two leaf-stalks, 30 to 50 cm. in height, bearing the trifoliate lamina, with an area of 100 to 250 sq. cm., and a single scape, 20 to 40 cm. in height, bearing a spadix enclosed by a hooded overarching space. The hood contains a large proportion of chlorophyll and sustains in greater part the functional activity of the leaf, and exhibits similar reactions to light and modified atmospheres. The correlation of growth is such that the scape and inflorescence attain full size within ten days from the opening of the bud, and the greater part of the leaf-expansion follows in the next ten days. During the first 10 days the starch stored in the corm is drawn upon to furnish an increasing amount of material for the growth of the aerial organs; during the next 10 days a decreasing amount is drawn from the corm, and usually after that time a stream of plastic material sets in the opposite direction from the laminæ, which is in part stored in the corm and in part used in the development of the lateral offshoots, which begin development at this time.

Effect of an Atmosphere free from CO_2.—Buds which had attained a height of 10 cm. were brought through an opening in a glass plate allowed to rest upon the top of the pot in which the plant was grown. The opening around the bud was securely sealed by means of wax, moulding clay, or the following device:—A cork stopper was perforated with an opening larger than the ultimate size of the sheathing bases of the petioles, and the upper part of the opening was enlarged to form a cup-shaped cavity. After the cork had been saturated with paraffin it was placed in the glass plate and enclosing the bud, the bottom of the cup-shaped cavity covered with a loose layer of asbestos or glass-wool, and over this was poured a layer of mercury 5 mm. in thickness

(see figure, p. 545). This method of sealing exerted no injurious pressure on the plant and allowed it to expand in a normal manner—a very important consideration in such experiments, where soft-stemmed herbaceous plants were used. The plant was covered with a bell-jar of a capacity of 4 to 8 litres, sealed to the glass plate, and provided with two tubulures. To one tubulure was fitted a series of potassium tubes or vessels containing potassium hydrate in solid form, and saturating a mass of asbestos fibre. The second tubulure was connected with an aspirator, by which the air was occasionally renewed. Several vessels containing 2 to 5 grams of solid potassium hydrate were placed inside of the bell-jar. The potassium absorbed water rapidly and soon dissolved. To provide against the dryness of the enclosed air thus induced, a large sponge saturated with water was placed near the plant. These precautions furnish normal conditions, except in the composition of the air, from which almost all the CO_2 is abstracted. It is, of course, understood, that the plant is constantly giving off this substance as a result of its oxidation processes, and it may be imagined as forming a diffuse stream from the plant to the vessels containing the potassium solutions. The amount actually present in the bell-jar at any time, however, must have been quite small. The potassium solutions were renewed once each week.

Plants of *Arisæma* grown in the apparatus described above exhibited a normal development during the opening of the bud and the preliminary stages of the unfolding of the leaves, which are crumpled in the bud, during a period of from 2 to 4 days. The unfolding process was arrested, however, at a very early stage, and the laminæ were unfolded only so far as to expose the dorsal surface, and the crumpled appearance was not lost. In 10 to 14 days after the beginning of the experiment, the laminæ assumed a yellowish colour, as a result of the decomposition of the chlorophyll, and other signs of deterioration appeared, ending in the death of the organ a few days later (see Plate XIX. fig. 2).

The structure and arrangement of the tissues had undergone but little differentiation from the forms present in the folded condition, and differed from the normal forms by the size of the single layer of palisade-cells and the globular form of the spongy parenchyma, and seemed, moreover, to be in a state of hunger. It is to be noted that the sheathing spathe also undergoes similar abnormalities; but since it is never folded, and since its development consists principally of a longitudinal expansion

of the cylindrical sheath and hooded tip, the more apparent deviation is one of size. The thickness is such as to prevent crumpling. It is to be noted, moreover, that the development of the spathe is usually accomplished before the leaves have begun maximal growth under normal conditions. If mature leaves were sealed into an apparatus similar to the above, no changes were discernible until 15 to 20 days later. At this time, the starch and other carbohydrates with which they were richly loaded having been used, a shrinkage was noticeable, and the leaf was found to be in a state of hunger. On restoration to a normal atmosphere before decay had begun, they were restored to a normal condition.

If the bell-jar described above were replaced by one with double walls enclosing a solution of potassium bichromate which permitted the passage of rays chiefly from the lower end of the spectrum, the plants grown in an air free from CO_2 exhibited a complete unfolding of the laminæ, and a total disappearance of the angles, in a period corresponding to the normal development of the leaf. In the period following the unfolding only a small amount of expansion occurred—a smaller amount than that of plants in normal air in similar light. At the end of the period of 10 days the laminæ were fully unfolded, bright green, and were recurved at the edges, but began to exhibit signs of deterioration. No marked increase in size had occurred.

Under light obtained by use of the double-walled chamber filled with ammonia-copper-oxide in normal air, the laminæ, by aid of the diffuse rays from the lower end of the spectrum, which accompanied the blue-violet rays, accomplished a development corresponding to that of plants grown in diffuse daylight. When grown in this chamber in an air free from CO_2 for a period of 10 days, the leaves remained in a folded position, were light green, and were beginning to exhibit signs of deterioration.

The two series of experiments last described were not repeated a sufficient number of times to confirm the above results, and certain disturbances of the apparatus render the results untrustworthy. In all the above experiments an examination of the corms was made, showing the presence of a considerable amount of starch at the conclusion.

Effect of Darkness.—In order to cultivate plants in darkness, but under otherwise approximately equal conditions, a bottomless chamber of galvanized iron, 1·5 m. × 1 m. × 1·75 m., was

constructed, and allowed to rest on a metal bench covered with a layer of moist sand to a depth of 5 cm. This dark chamber was placed in such a position that the sun's rays did not strike it, and was attached to a simple pulley, by which it might be raised and lowered to allow an occasional examination of the plants.

Awakening plants with bulbs 4 to 6 cm. long., when placed in this chamber, showed a greatly exaggerated development of the bud-scales, a rapid elongation of the scapes and petioles, during 5 to 8 days, attaining a length nearly double the normal. The daily increase of these organs in some instances amounted to 12 cm. The laminæ in some instances were carried completely or almost completely through the unfolding stage, but were rarely able to attain a full extension, or area much in excess of the folded condition, and owing to the absence of the directive influence of light assumed various positions with respect to the horizontal. The process of decay did not begin until 15 to 20 days after the beginning of the experiments, and if the plants, after unfolding, were brought into diffuse light with gradually increasing intensity the normal appearance was finally resumed. The colour of the etiolated leaves was of the customary waxy yellow, upon which the reddish-purple colour areas characteristic of the external tissues were boldly apparent. The spathe exhibited great variety of reaction, but in general it did not attain full development. This was the invariable result if this member alone was enclosed in a covering excluding light; and although not responsive to the directive action of light or gravity, it assumed an upright or outwardly recurved position in darkness (see Plate XIX. fig. 3).

If plants with mature leaves were placed in the dark chamber, a renewed activity of the petioles occurred lasting 2 or 3 days, and in 4 or 5 days the laminæ began to bleach and decay.

Effect of Diffuse Light.—Plants grown in a diffused light exhibited features of development in general analogous to those shown in darkness. Elongation of the petioles and scape, dwarfing of the spathe, especially the overarching hood, occurred. Still more marked, however, was the restriction of the area of the laminæ, corresponding to the intensity of the light.

Removal of concurrent Members.—In order to determine how far the diversion of food from certain members and its concentration in one might affect its development, recourse was had to the removal of two of the three aerial members of plants grown

in a dark chamber. If the leaves were removed, no changes resulted in the development of the scape or spathe. The latter organ was dwarfed as usual, although not more than 30 cm. from the stored food in the corm. If the scape and one leaf were removed from a plant emerging from the bud in a dark chamber, the remaining leaf exhibited a development quite similar to those of entire plants under similar circumstances, except that the petiole reached a length much in excess of those on an entire plant. The laminæ were extended in such manner as to cause the disappearance of the angles of the leaf-folding in the bud. They soon became recurved at the margins, and only a small increase in size occurred after unfolding.

The removal of one leaf and the scape from plants grown in an air free from CO_2 resulted in a somewhat more complete development of the laminæ than in an entire plant under the same circumstances. The angles taken on in the bud completely disappeared; an approximately normal green colour, and a position quite similar to that of plants in free air, were assumed. The amount of food available for development must have been two or three times as great as that usually afforded a single leaf. In 12 to 14 days, however, the laminæ began to exhibit signs of deterioration; but if at this time they were removed from the apparatus and placed in the open air a normal condition was restored, and development proceeded in the usual manner (see Plate XIX. fig. 4).

Comment.—The leaves on an entire plant of *Arisæma* are incapable of development beyond the unfolding stage in an atmosphere free from CO_2. If two of the three aerial members are removed, the remaining one may attain a more advanced stage of development. In darkness the petioles are greatly elongated, and unfolding of the laminæ takes place, but no expansion of their area ensues. The removal of concurrent members results in an exaggerated extension of the petiole, but has no effect on the laminæ. A similar result is obtained with the spathe under both conditions. It is to be noted that in light the removal of concurrent organs results in an increased development of the laminæ, and in darkness of the petiole.

Oxalis floribunda, Lehm., and *O. vespertilionis*, Zucc.

The first-named species was furnished with a tuberous rhizome, 1 to 2 cm. in diameter and 2 to 4 cm. in length, densely charged

with storage material. From the upper nodes of the rhizome arose a score or more of leaf- and flower-stalks in all stages of development. Plants of the second species (obtained from Texas) were furnished with a scaly bulb 1 to 2 cm. long, and 1 cm. in diameter in the thicker portion. From each of the axils of a few of the upper scales arose a solitary leaf-stalk, with laminæ in various stages of development.

Effect of an Atmosphere free from CO_2.—Plants placed entirely inside the apparatus described above, in such position that protection was afforded from the rays of the mid-day sun, offered in connection with the reactions in darkness exactly the opposite results from those obtained by Jost with *Mimosa.* The diffuse light caused a slight elongation of the stems, although still of such intensity as to cause the daily movements of laminæ. These periodic movements continued in an apparently normal manner during the entire continuation of every experiment—13 to 20 days. At the expiration of this time the mature laminæ were healthy, and their further existence corresponded closely to that of similar organs in the open air. The younger leaves carried on normal development, the laminæ acquiring the power of carrying on the nyctitropic movements at the usual time, but contained less chlorophyll perhaps than corresponding members in the open air. After the completion of the experiment, both the younger and the older leaves continued unchanged, and plants which were under observation during a period of 90 days offered no marked divergence from the normal forms.

Effect of Darkness.—The leaf-stalks exhibited a slightly exaggerated elongation, and the laminæ attained only an incomplete stage of development, remaining in a folded position. A similar behaviour of *O. Deppei* and *O. lasiandra* was observed by Jost (5).

Removal of concurrent Organs.—The removal of concurrent buds or members in no wise altered the development of those remaining, whether in darkness or in air free from CO_2.

Comment.—Plants of this type, of which *Isopyrum* is also an example, are able to carry on leaf-development in a perfectly normal manner at the expense of stored food. Furthermore, it is seen that the existence of the chlorophyll and the motility of the pulvini are entirely independent of the food-forming processes in the leaf. This latter conclusion is confirmed by the observations of Jost, in which the pulvini of *Mimosa, Acacia,* and *Phaseolus* retained motility for many weeks in darkness.

Trillium erectum, Linn., and *T. erythrocarpum*, Michx.

The specimens used were furnished with a premorse tuberous rhizome, from the apex of which arose a single bud. The rhizome was densely charged with starch. Ordinarily the bud develops a stem 8 to 15 cm. high, bearing at the top a whorl of three ovate, obovate, or oblong leaves imbricated in the bud around the single stalked flower.

Effect of an Atmosphere free from CO_2.—Plants grown in an atmosphere free from CO_2 exhibited a normal development of the leaves, which attained full size in a period of from 10 to 12 days, except that the laminæ were lighter in colour, due to the smaller proportion of chlorophyll present. The plants were not capable of continued existence in the apparatus, or even until all of the reserve material in the rhizome was exhausted, since destructive fermentations generally set in at this time.

Effect of Darkness.—In darkness the stems undergo only a slightly exaggerated development; in some instances the minimum measurement for the species was shown. The peduncles show no increase in size, and the laminæ loosely retained the imbricated position held in the bud with no increase in size. These conditions could not be altered by the removal of any of the concurrent members.

Comment.—In light the leaves are capable of expansion so far as food-material is available. In darkness a minimum of growth ensues.

Isopyrum biternatum, Torr. & Gray.

Plants of this species consist of a short woody rhizome, from which arise stems 11 to 20 cm. in height bearing a number of small trifoliate leaves. Depending from the rhizomes is a dense tangle of fibrous roots, which are thickened in such manner as to form numerous tubers, containing a large proportion of sugar and starch. The proportion between the amount of stored food and the mass of the aerial stems and leaves to be developed at its cost is about the same as in the *Oxalis* material used.

Effect of an Atmosphere free from CO_2.—Young plants on which were borne leaves barely emerged from the bud, and others still in a folded condition, showed a continuation of the normal development of these organs during the continuation of the experiment over a period of from 14 to 20 days. During this time many of the leaves attained full size, and exhibited a

perfectly natural aspect. Mature leaves gave no indication of deterioration during the above period.

Effect of Darkness.—In darkness the leaf- and flower-stalks elongated rapidly, but when they reached a length slightly in excess of the normal began to deteriorate and soon died. The laminæ and the floral envelopes were imperfectly developed.

Removal of concurrent Members.—The removal of younger or older stems or of leaf- or flower-stalks in no wise affected the development of the remaining organs.

Comment.—*Isopyrum* resembles *Oxalis* in that it is able to carry on the formation of perfect leaves in the sunlight in an atmosphere free from CO_2 so long as stored food-material is available. The existence of chlorophyll in this plant is independent of its functional activity.

Calla palustris, Linn.

This plant consists of a creeping rhizome 1 to 2 cm. in thickness, from the apex of which arise a few cordate leaves with petioles 15 to 20 cm. long, and one or more solitary scapes 8 to 15 cm. high. The relatively large rhizomes are filled with stored food.

Effect of an Atmosphere free from CO_2.—Plants brought into a warm house and placed under the apparatus described above exhibited a development of the petioles and laminæ during a period of from 10 to 12 days that resulted in the formation of perfect leaves. During this period the mature leaves offered no signs of deterioration. The continued existence of the plant, however, under such conditions was impossible, because of the destruction of the stored food by fermentation. In this particular a resemblance to *Trillium* is exhibited.

Effect of Darkness.—In the dark chamber a slight extension of the petioles occurred, while the laminæ attained a size equal to those in the open air, although they were recurved at the margins. No effects were obtained by the removal of the concurrent members.

Comment.—The most noteworthy feature in the experimental results obtained from *Calla* is that of the attainment of full size by the laminæ of leaves grown in darkness.

Justicia, sp.

A woody plant, 1·5 cm. in diameter at the base, was divided at a height of 30 cm. into two branches, 10, 20 cm. long respectively. Both branches were growing actively, and the apex of each held a bud, one pair of rapidly expanding upright leaves, one pair of leaves of mature size in a horizontal position, and several pairs of leaves depending downward in the "rainfall" position described by Stahl.

Effect of an Atmosphere free from CO_2.—The shorter branch described above was introduced into the apparatus in such manner that the bud, the youngest pair, and the horizontal pair of leaves only were included. During the 17 days through which the single experiment with this plant was carried, the development of the bud and young leaves, and the existence of the mature leaves, exhibited no divergences from the normal, and after removal from the apparatus growth was continued in such manner that the leaves which had been enclosed were not distinguishable from others of the same age.

Hibiscus Rosa-sinensis, Linn.

The one specimen used in this experiment consisted of a number of woody shoots 1·5 m. in length, springing from a main trunk near the surface of the soil. Each shoot was furnished with a large number of active leaves, and the rate of growth was very slow.

Effect of an Atmosphere free from CO_2.—The terminal portion of a shoot, 4 cm. in length, holding a leaf 3·5 cm. long and an apical bud, was sealed into the apparatus, where it remained for a period of 32 days. During this time several young leaves were unfolded, and the older one had attained a length of 6·5 cm., approximately equal to that of a normal leaf of the same age. The green colour was not so intense as in leaves in the open air.

Comment.—Justicia and *Hibiscus* offer similar conditions to those afforded by *Ficus* and *Æsculus,* which were tested by Corenwinder (2). The tips of young plants of *Ficus* were not able to form perfect leaves, while older specimens of *Æsculus* were able to do so. The great leaf-surface exposed on the free portion of the older plants would afford an ample supply of surplus material, which would be available for the slowly developing leaves.

Lilium tigrinum, Ker.

Young plants with small scaly bulbs, known to the gardener as "3rd size," were obtained, but only in such limited quantity that but few experiments were carried out.

Effect of an Atmosphere free from CO_2.—Entire plants placed in the apparatus were able to form perfect leaves. The death of the older leaves near the base of the stems occurred in the same manner as in normal plants. A general resemblance appears between the behaviour of this species and *Trillium*.

Zea Mays, Linn.

Seedlings were grown from selected grains placed in small pots of earth in the usual manner.

Effect of an Atmosphere free from CO_2.—Seedlings with the shoot emerging from the cotyledon were placed entirely inside the apparatus, where they remained for a period of from 8 to 12 days. In such experiments, the plant evidently could carry on the extension of the shoot and leaves only so long as food could be obtained from the seedling. To determine the actual constructive value of the stored food in the seed, plants were allowed to remain in the apparatus until the leaves exhibited indications of deterioration, which was from 11 to 14 days after the beginning of the experiment. The plants were more slender and the leaves narrower than in control plants. A small amount of starch was still to be observed in the seeds, both in the plants grown in the air free from CO_2 and in normally grown plants of the same age (see Plate XIX. figs. 5, 6).

Effect of Darkness.—In darkness the stems are elongated and the etiolated leaves are much narrower than in normal plants.

Phœnix dactylifera, Linn.

Specimens were obtained by the germination of the seeds of the commercial fruit, a process requiring from 20 to 30 days. The seed consists largely of reserve cellulose, and, according to Haberlandt, it is sufficient to allow the formation of a primary root more than a metre in length before the unfolding of the first foliage-leaf, in the natural habitat of the plant. In my experiments the planting of the seeds in moist soil made this excessive development of the root useless, and foliage-leaves began to unfold when the root had attained a length of a few centimetres.

Effect of an Atmosphere free from CO_2.—The seedlings grown in small pots were placed inside the apparatus for a period of 30 to 40 days. The leaves which, at the beginning of the experiment, were emerging from the sheathing scale, exposing a tip 1·5 to 2 cm. in length, attained a length of 15 cm. and a complete normal expansion, corresponding to that of organs grown in the open air. Such leaves usually attain a length of 20 to 30 cm. by a slow process of growth lasting several months, and my experiment therefore covers only the earlier stages of development.

Effect of Darkness.—Specimens placed in a dark chamber during a period of from 30 to 40 days exhibited an exaggerated elongation of the cotyledonary and leaf-scales, as well as the leaf itself, which retained its lamina in the plicately folded position. The increase in length amounted to 20 to 30 per cent. more than in control plants.

Comment.—The development of seedlings of *Zea* and *Phœnix* may proceed so long as the necessary amount of plastic material is available. In *Zea* the amount is sufficient to allow a normal development for a period of 10 to 12 days, and in *Phœnix* for a much longer period.

INTERPRETATION OF EXPERIMENTAL RESULTS.

The first and most apparent conclusion to be drawn from a consideration of my own and other experiments, is that the leaves of different species exhibit individual reactions to an atmosphere free from CO_2. For the better comprehension of such reactions, it will be found convenient to divide the existence of the leaf into three periods, instead of two as has been done by Vöchting. The first includes the growth and development of the leaf from a rudimentary condition to the unfolding of the lamina, corresponding to a similar period outlined by Vöchting. The second includes the unfolding and expansion of the lamina to such extent as to attain a normal stature; and the third includes the existence of the organ after maturity has been reached. A disregard of the conditions attendant on the two last-named periods has led to the formulation of contradictory conclusions from the use of the same material in the hands of different investigators.

All the plants hitherto examined by myself and others with respect to the relation of the leaves to the air have been shown

to carry on the development of the leaves during the first stage, *i. e.* from the rudimentary condition to the unfolding of the leaves, without regard to the amount of CO_2 in the air, unless the proportion should be so great as to greatly diminish the volume of the oxygen.

The greatest divergences of reaction appear during the second or unfolding stage. The leaves of some plants quickly perish at the beginning of this stage if in an atmosphere free from CO_2; others carry on a more or less complete development before perishing; others attain a size somewhat less than the normal, and then continue to live in an apparently healthy manner; and others attain a natural size, and continue existence showing no deviation from the normal.

Thus Vöchting (**10**) found that the leaves of *Solanum*, *Tropæolum*, and *Mimosa* exhibited signs of deterioration in from 3 to 8 days after unfolding began; and Jost (**5**) obtained the same result with *Mimosa*, and *Arisæma* exhibited similar reactions in my own experiments. De Saussure (**8**) found that the leaves of *Lonicera*, *Prunus*, *Ligustrum*, and *Amygdalus* began to perish in 12 days. Corenwinder (**2**) found that leaves on a young shoot of *Ficus* perished after an exposure to an air free from CO_2 for a month, and, later, in an experiment with a branch of an older specimen of *Æsculus*, obtained a normal development. Vöchting (**10**) found that the leaves of *Cardiospermum* finally perished in an atmosphere free from CO_2, although able to attain a normal size; and in my own experiments *Trillium*, *Calla*, and *Lilium* exhibited similar reactions. Godlewski (**3**) found that seedlings of *Raphanus* were able to form normal leaves; and Vines (**9**) obtained the same results with seedlings of *Cucurbita*, *Ricinus*, *Phaseolus*, and *Zea*, and with tips of branches of *Cardiospermum*, *Dolichodeira*, and *Helianthus*. It is to be noted, however, that in this last-named series the experiments were carried only through a period of 8 to 10 days, and that the leaves of the species named were approximately equal to those of control plants only. In Vöchting's tests *Cardiospermum* was able to form leaves hardly equal to the normal, which soon perished; and in my own tests with *Zea*, divergences from the normal were shown in 10 days and deterioration soon followed. The tests made with *Phœnix* were not of sufficient duration to determine the point at which the deterioration due to the exhaustion of the food-supply occurs.

Isopyrum and *Oxalis* are capable of forming perfect leaves which are capable of continued normal existence, inferentially, until the supply of plastic material becomes insufficient. Leaves attained full size and continued a normal existence on *Æsculus* in Corenwinder's tests, on *Fagus* in those of Jost's, and on *Hibiscus* and *Justicia* in my own.

Furthermore, it is shown that the behaviour of leaves in an atmosphere free from CO_2 and in darkness exhibits the greatest divergences. Thus the leaves of *Mimosa* and *Phaseolus* may attain normal size in darkness, but quickly perish in an air free from CO_2. Exactly the reverse relations prevail in *Isopyrum* and *Oxalis*. The accompanying alterations in the growth of etiolated plants still further warrant my assumption that the behaviour of such plants cannot be held to be analogous to that of specimens grown in an air free from CO_2, and that in the former many other forces are operative in the production of the "rigour of darkness" besides those concerned in food-formation.

Since the growth of a plant in an atmosphere free from CO_2 practically suspends the food-forming processes, I have deemed it of the greatest importance to analyze the relations existing between the growth of such organs and the supply and conduction of food from storage organs or from other members.

A special series of tests was made by myself with *Zea* with reference to this point, and it was found that marked reactions might be seen after 10 days. The control plants exhibited a more vigorous growth, and on the 12th to 14th day deterioration began in the leaves grown without CO_2 (see Plate XIX. fig. 5). The reserve food was not exhausted in the seeds of either the enclosed or control plants. This result leads to the conclusion that seedlings may not develop normally beyond a certain point at the expense of stored food in the seed, contrary to the views of Batalin (1). The rapidly increasing needs of a seedling are usually partially met by substances formed in the young leaves after a certain stage of development has been reached. If, on the attainment of this stage of development, it is still compelled to depend on the supply from the seed, deterioration will soon ensue. While the growth of the leaf, or rather its consumption of plastic material, may be represented by a logarithmic curve during the period of rapid expansion, the amount of food which may be conveyed to it may be represented by an algebraic curve. The cross section of the conducting

tissues will increase, as Jost has shown, in direct relation to the mass of the leaves, the fermentative processes will be controlled by the regulatory mechanism in like manner; but the increasing distance separating the leaf, the heightened difficulty in the way of drawing the reserve food from the more distant parts of the seed, and the constantly diminishing quantity of material available, due to its use and the intervention of destructive fermentations, will be such that the curves representing the needs of the leaf and the supply furnished will intersect before all of the material is exhausted. The point of intersection of these two lines marks the period beyond which development may not normally proceed without food-formation in the leaf. This period occurs at a time which is determined by the relative value of the factors entering into the formation of the two curves. In *Zea* it appears in 10 to 12 days after germination and in *Phœnix* at a much later period. The above generalizations would also apply to specimens of *Arisæma* and *Solanum* growing from tubers. By the removal of concurrent members from the former it has been shown that the point of intersection of the two curves may be set forward—a condition holding good also for *Mimosa* and *Phaseolus* in the darkness, but which has not been tested in light and in an air devoid of CO_2. In *Trillium*, *Calla*, and *Lilium* the intersection of the curves does not occur until the attainment of normal stature of the leaves. In *Oxalis* and *Isopyrum* the intersection would not occur until some time after the formation of the leaves. In fact, if the tubers or rhizomes of these plants were deprived of all buds except one, this bud should be able to carry on development throughout an entire season or even longer at the cost of the disproportionately large amount of stored food available. The leaves of *Justicia*, *Hibiscus*, *Fagus*, and *Æsculus* carry on development at such a low rate that the chlorophyll areas of the unenclosed leaves are able to furnish a food-supply at all times equal to the needs of the enclosed organs, and hence the curves do not intersect, and the enclosed leaves are capable of perfect development and continued existence.

In the light of my own experiments, it is difficult to accept the conclusion that the deterioration of leaves in an air free from CO_2 is due to the pathological effect of the disintegration of chlorophyll consequent upon its functional inactivity, as proposed by Jost (5). The ability of many growing and mature leaves to withstand the action of air free from CO_2 for extended periods, and the

alteration of the time of deterioration by the removal of concurrent members, conclusively discredit such a theory. These conditions, together with the fact that the leaves are in a state of hunger, point more especially to the conclusion that the destruction of the leaf is due to insufficient nutrition. Furthermore, such deterioration does not always occur earlier in plants in the light than in those in darkness, as Jost concludes. It must be added in this connection that it is not impossible that the regulatory mechanism may play a part in the diversion of plastic material or withdrawal of protoplasmic substance from the leaves. In this case, however, the disintegration would accompany, instead of precede, the disintegration.

Incidentally to the results discussed above the following conclusions are sustained:—

1st. Material constructed in active chlorophyll areas and stored in special organs may be transported to inactive chlorophyll-bearing organs in some plants in light and in darkness, and be used in such manner as to allow of the perfect development of these organs.

2nd. The removal of concurrent members in darkness may have no effect, may cause an exaggerated development of the petioles, or may result in the perfect development of the entire leaf. The nature of the regulatory mechanism in each instance must be entirely specific.

3rd. It is possible for some plants to form perfect leaves in darkness, some when a portion of the stem only is darkened, and others when the entire plant is etiolated. It is thus shown that no invariable connection exists between the phototonic condition and leaf-development.

4th. The conclusion of Jost, that pathological conditions ensue more quickly in inactive leaves in light than in darkness, is not capable of general application. The deterioration in certain plants appears as quickly in darkness as in others in light.

5th. Placing a leaf under such conditions that it cannot construct food-material sets in motion the specific regulatory mechanism of the organism in such manner that the plastic material may be withdrawn and the organ cast off. An exaggerated development of the petioles may be induced in darkness by this mechanism.

6th. It is to be noted that plants may not be entirely classified as to their reaction to an atmosphere devoid of CO_2 upon the basis of species, since a given plant may be capable of developing inactive leaves at one stage of its development, and not at another. This is evident upon consideration of the fact that such capacity is entirely dependent upon the availability of the reserve food for this purpose.

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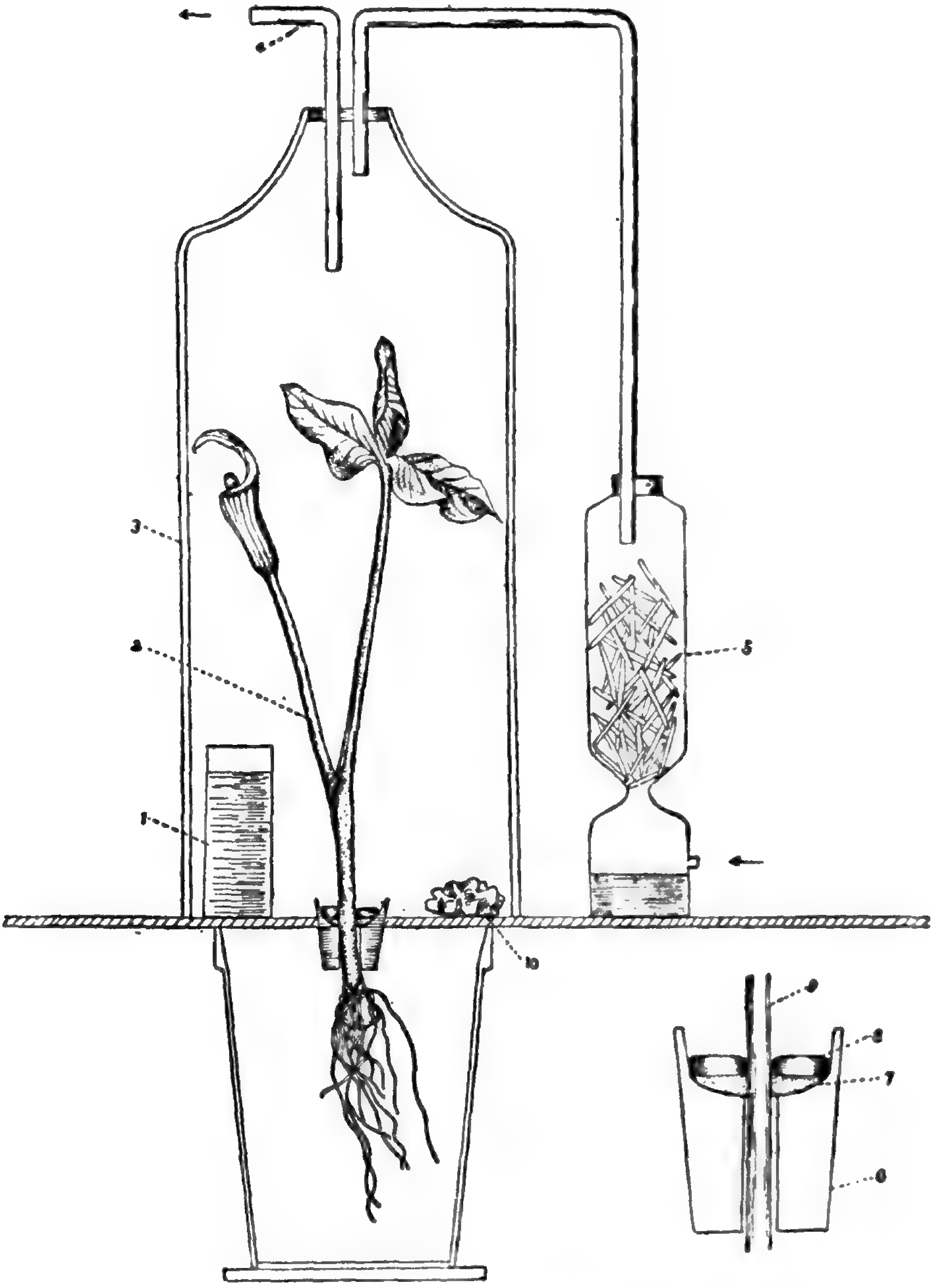


Apparatus for growing plants in an atmosphere free from CO_2.

1. Dish containing solution of potassium hydrate.
2. Specimen of *Arisæma triphyllum* 10 days after opening of bud.
3. Receiver of 10 litres capacity.
4. Outlet-tube connected with aspirator.
5. Sticks of potassium hydrate and moist asbestos fibre.
6–9. Detail of method for sealing plant in receiver.—6. Cork. 7. Asbestos fibre. 8. Mercury. 9. Stem of plant.
10. Sponge saturated with water.

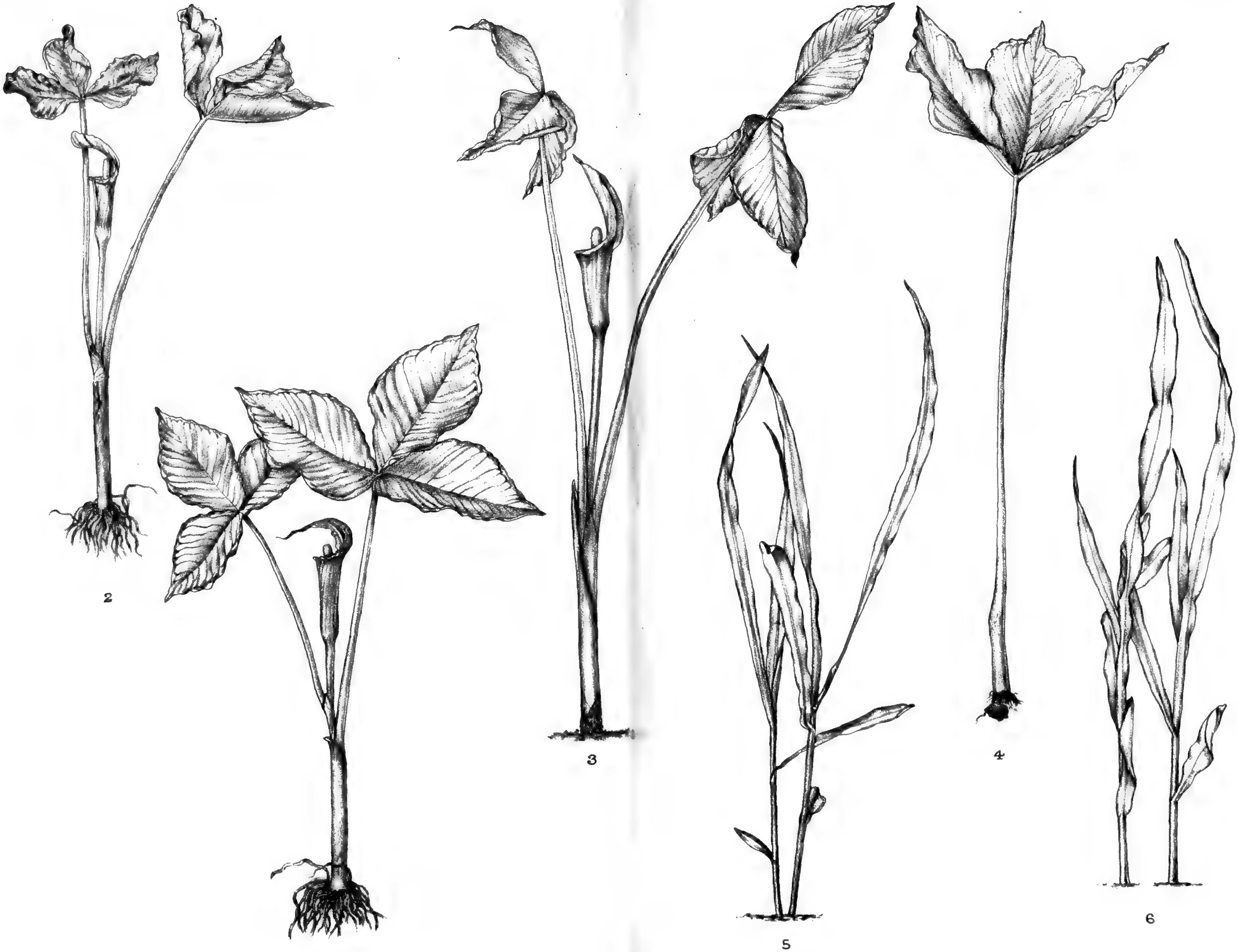
EXPLANATION OF PLATE XIX.

Arisæma triphyllum.—Fig. 1. Specimen grown in open air. Fig. 2. Specimen with aerial members grown in an atmosphere devoid of CO_2. Fig. 3. Specimen grown in darkness. Fig. 4. Specimen from which one leaf and the flower-scape were removed, grown in an atmosphere devoid of CO_2.

Fig. 5. Specimens of *Zea Mays* grown in an atmosphere devoid of CO_2.

Fig. 6. Normal specimens of *Zea Mays.*

(The specimens of *Zea* were photographed in an inverted position.)



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express my thanks to Prof. P. MacOwan, F.L.S., and H. Bolus, Esq., F.L.S., for allowing me to examine those contained in the Cape Government Herbarium and Mr. Bolus's private herbarium; also to the various friends who have supplied me with the new species here described.

Crassula (§ Eucrassula) Galpini, *Schönland*, n. sp.—Perennis humilis glaberrima e basi ramosa; ramuli crassi dense foliati; folia subconnata lanceolata obtusa suberecta dorso convexa marginibus integris, vel planiuscula apice serrata, ±10 mm. longa; inflorescentia lateralis pedunculata pedunculo albo teretiusculo circa 60 mm. longo sparse foliato, cymæ axillares floribus pedicellatis, pedicellis ad 12 mm. longis; sepala crassa dorso convexa inæqualia persistentia, 2 mm. longa; petala radiata ovata marginibus medio reflexis, c. 4 mm. longa; filamenta lineata apice attenuata, antheræ ovatæ; ovaria brevia, lateraliter depressa, styli brevissimi; squamæ minutæ subrhombeæ.

Described from two living specimens; named in honour of Mr. E. E. Galpin, F.L.S.

Hab. "Summit of Andriesberg, near Queenstown," alt. 6700 ped. Leg. E. E. Galpin (no. 2000), Feb. 23rd, 1896.

This species, which is not nearly allied to any species of *Crassula* with which I am acquainted, exhibits several interesting features which are worth mentioning. When the flowers open, the filaments are very small and closely appressed to the carpels. At this stage the anthers lie in hollows, each of which is formed by the depressions formed by two contiguous ovaries. Soon afterwards one of the filaments elongates to its final length, and is placed in such a position that an insect trying to get at the nearest nectar-glands (the "squamæ" of descriptive botany) has to touch the now open anther borne by this filament. Soon afterwards a second stamen goes through the same performance, until at last all five stand in a position most favourable for the pollen to be carried away. The styles all this while are extremely small and closely packed together; but as soon as the last stamen has risen they elongate very slightly, curve outwards, and become receptive. Thus we have here a very pronounced proterandrous flower. The gradual ripening of the stamens is, I believe, unique amongst crassulaceous plants, and reminds one very forcibly of the well-known case of *Parnassia palustris*.

A further interesting point in the morphology of this plant is the curious dimorphism of the leaves. I received two live plants from Mr. Galpin, one of which I planted in my garden. The vegetative shoots bore thick entire leaves; but as they elongated they produced about four pairs of leaves which were very much thinner, and were serrate at the apex, showing 3–4 serrations on each side; these serrated leaves were succeeded on the same shoots by perfectly entire leaves.

As in *Crassula cordata*, Ait., and *C. multicava*, Lemaire, vegetative shoots are produced as accessory shoots in the floral region, and one peduncle was observed to produce a vegetative shoot at its apex when the flowering-period was over.

The colours of the different organs of this plant are also very peculiar. The leaves are white at their bases, this colour passing gradually into a pale green, and, in the older leaves, this colour further passes gradually into a crimson which is deepest at the tip. The peduncles and pedicels are almost pure white, the sepals are pale green, the tops of the petals white, the lower parts of the petals, filaments, nectar-glands (or "squamæ"), and the carpels are crimson, the anthers blackish, the pollen yellow.

Crassula (§ Eucrassula) swaziensis, *Schönland*, n. sp.—Suffruticosa erecta ramosa 15 cm. longa; caudex efoliatus 3 cm. longus, ramis dense foliatis 2–3 cm. longis; folia carnosa perfoliata obovata vel spathulata subglabra 2·5–3 cm. longa marginibus ciliatis; inflorescentiæ terminales multifloræ cymoso-corymbosæ, pedunculi pubescentes graciles 7–8 cm. longi, foliis 2 pubescentibus parvis ornati; bracteæ parvæ ovato-lanceolatæ, bracteolæ lanceolatæ, omnes dorso pubescentes; cymæ pedunculatæ capitatæ floribus subsessilibus; sepala sublibera lanceolata obtusiuscula carinata dorso pubescentia 2 mm. longa; petala alba (?) sublibera obovata recurvata apice dorso mucronata; filamenta filiformia antheris ovatis; ovaria parum curvata, stylis quam ovaria fere æquilongis recurvatis, squamæ membranaceæ cuneato-spathulatæ.

Described from two dried specimens in Herb. Albany Museum, also in Herb. Galpin and Herb. Kew.

Hab. "Havelock Concession, Swaziland," alt. 2500 ped. Leg. E. Saltmarshe. Herb. E. E. Galpin, no. 992.

This species may be placed in Harvey's sect. "*Perfilatæ*," although it is very different in habit from the other species which have been united by Harvey in this section.

Crassula (§ Eucrassula) laxa, *Schönland*, n. sp.—Suffruticosa ramosa glaberrima; folia sessilia connata planiuscula lanceolata acuminata recurvata c. 10 mm. longa; internodia 2 mm. longa; inflorescentiæ cymosæ terminales pedunculis brevibus; flores pedicellati campanulati; sepala sublibera lanceolata obtusa, c. 1·5 mm. longa; petala libera ovato-lanceolata obtusa apice subumbonata, c. 3·5 mm. longa; filamenta lineata apice attenuata, antheræ ovatæ; ovaria gracilia, styli subulati; squamæ minutæ cuneatæ apice emarginatæ.

Described from two living plants received from Mr. E. E. Galpin.

Hab. "Andriesberg, near Queenstown," alt. 6600–6700 ped. Leg. E. E. Galpin (no. 2002), Feb. 23rd, 1896. "In rupestribus, Bariga trans. fl. Bashee," alt. 2400 ped. Leg. Baur (no. 629 in Cape Government Herbarium), Feb.

This species is nearly allied to *C. fruticulosa* (L. ?), Haw.; but it is distinguished by its shorter and flat leaves, its nearly sessile inflorescences, and its comparatively longer sepals. The older branches have a very characteristic loose appearance; hence I have called the plant *C. lâxa*, although this character is not always apparent in dried specimens; in young branches, however, the leaves are closely imbricated, and remind one of *C. ericoides*, Haw. In fact this plant forms a very striking connexion between Harvey's section "*Subulares*" and "*Imbricatæ*." As regards the colour of the flower, the sepals are green with rosy tips, the petals and filaments creamy white, the anthers are reddish brown, the pollen pale yellow, the nectar-glands green below and rosy above.

Crassula (§ Eucrassula) parvisepala, *Schönland*, n. sp.—Suffruticosa ramosa; rami annulati efoliati; ramuli foliati internodiis 4–6 mm. longis; folia subconnata subulata teretia (?) basi attenuata apice acuminata 1·2–2 cm. longa; inflorescentiæ terminales cymoso-corymbosæ, pedunculis brevibus, bracteis bracteolisque brevibus lanceolatis; flores campanulati pedicellati, pedicellis 4–5 mm. longis; sepala basi connata 1 mm. longa lobis ovatis extus carinatis; petala alba sublibera obovato-linguæformia apice dorso mucronulata, 4–5 mm. longa; filamenta linearia apice attenuata, antheris ovatis; carpella gracilia, stylis brevibus subalatis, squamis minutis crassis subrectangularibus.

Described from a dried specimen in Herb. Albany Museum, also in Herb. E. E. Galpin and Herb. Kew.

Hab. "Saddleback mountain near Barberton," alt. 4500–5000 ped. Leg. E. E. Galpin (no. 979), July 1890.

This very distinct species may be placed amongst Harvey's sect. "*Subulares*," in which it is conspicuous by its rather small sepals.

Crassula (§ Eucrassula) Southi, *Schönland*, n. sp.—Suffruticosa, virgata, c. 20 cm. alta; caulis annulatus ramis ramulisque dense foliatis glabris internodiis c. 4 mm. longis; folia planiuscula ovato-lanceolata perfoliata mucronata subglabra c. 13 mm. longa marginibus cartilagineo-ciliatis; inflorescentiæ terminales laxe corymbosæ subsessiles bracteis bracteolisque lanceolatis marginibus cartilagineo-ciliatis floribus pedicellatis pedicellis c. 5 mm. longis; sepala basi connata lanceolata subacuta glabra 2·2 mm. longa; corolla campanulata, petalis albis subliberis oblongo-ovatis carinatis apice dorso mucronulatis 3–3·5 mm. longis; filamenta sublibera filiformia apice attenuata, antheris ovatis; carpella oblique ovalia, stylis brevibus, squamis minutis.

Described from several living and dried specimens, and named after its first discoverer, Mr. B. South of Grahamstown.

Hab. "Lower Albany, near Port Alfred." Herb. Albany Museum, no. 841. Leg. B. South, Dec. 1893. "Evelyn Valley, near Kingwilliamstown," alt. 4000 ped. Leg. T. R. Sim (no. 1271), Jan. 1894.

This very distinct species belongs to Harvey's section "*Marginales*," and is nearly allied to *C. vaginata*, with which, however, it cannot be confounded. Mr. South informs me that it is not uncommon in Lower Albany; and it seems to me strange that it should have been overlooked by the numerous collectors who have visited this district. It becomes more strange still when we consider that Mr. South's locality cannot be more than a few hundred feet above sea-level, while Mr. Sim's specimens were collected 4000 feet above sea-level, thus showing that the plant has a very wide range in altitude, which may lead us to infer that it also is probably distributed over a large area; but as I have never seen any other specimens of it, nor have come across a description fitting it, I must consider it to be undescribed.

Crassula (§ Eucrassula) compacta, *Schönland*, n. sp.—Perennis pumila 4–5 cm. alta; folia subrosulata late obovata glabra carnosa 1·3–2 cm. longa 1–1·5 cm. lata marginibus incrassatis dense ciliatis; inflorescentiæ terminales vel laterales

3–3·5 cm. longæ paniculatæ subspicatæ, pedunculis brevibus crassis pubescentibus, bracteis obovatis acuminatis subconnatis, bracteolis lanceolatis marginibus ciliatis; flores pedicellati pedicellis 4 mm. longis; sepala sublibera lanceolata obtusiuscula dorso carinata extus pubescentia 3 mm. longa marginibus ciliatis; petala alba (?) sublibera obovato-lanceolata apice dorso mucronulata, 4–5 mm. longa; filamenta filiformia apice attenuata, antheris ovatis; ovaria oblique ovata, stylis brevissimis, squamis minutis apice emarginatis.

Described from three dried specimens in Herb. Albany Museum; also in Herb. E. E. Galpin and Herb. Kew.

Hab. "Stony ground, summit of Saddleback mountain near Barberton," alt. 5000–5300 ped. Leg. E. E. Galpin (no. 1092), Sept.–Oct. 1890.

This species must be referred to Harvey's sect. "*Marginales*," amongst which, however, it stands quite by itself. It is nearly allied to a species collected by Mr. J. M. Wood at Inanda in May 1880, and forming his number 551; and on examining more material they may prove to be identical. Wood states that the colour of the flowers is yellow, which may also be the case with Galpin's plants; but in Wood's specimens which are preserved in the Cape Government Herbarium the stem is elongated, and the leaves consequently further apart than in Galpin's specimens; in the former the leaves are, moreover, ovate and distinctly acuminate, and the peduncles much thinner and subglabrous. These differences may perhaps be due to climatic causes.

CRASSULA (§ EUCRASSULA) SCHLECHTERI, *Schönland*, n. sp.—Humilis perennis e basi ramosa, 4–5 cm. alta; rami rubri laxe foliati retrorsim hispidi, internodiis inferioribus 8 mm. longis; folia obovata sessilia subconnata scabra marginibus cartilagineo-ciliatis, inferiora 6 mm. longa superiora 3–4 mm. longa; inflorescentiæ terminales subsessiles cymoso-capitatæ, bracteæ bracteolæque lanceolatæ acuminatæ marginibus cartilagineo-ciliatis; flores pedicellati pedicellis 2 mm. longis; sepala sublibera glaberrima lanceolata petalis fere æquilonga; petala rufescentia (?) obovata apice dorso mucronulata 2–3 mm. longa; filamenta filiformia, antheris ovatis; carpella gracilia, stylis subulatis quam ovaria fere æquilongis, squamis . . . .

Described from several dried specimens in Herb. Albany

Museum. Named after Mr. R. Schlechter, to whom we owe so many discoveries of new South-African plants.

Hab. "Van Reenen (Drakensberg)," alt. 5500 ped. Leg. R. Schlechter (no. 6916), March 1895.

This species belongs to Harvey's section "*Squamulosæ.*" It can be recognized at once amongst its allied species by its comparatively large and perfectly glabrous sepals.

Crassula (§ Eucrassula) elongata, *Schönland,* n. sp.—Caulis debilis decumbens parce foliatus teres indistincte striatus subglaber albus internodiis 2·5–4 cm. longis; folia herbacea cordata acuminata petiolata petiolis subconnatis 3–5 mm. longis, laminæ 6–9 mm. longæ marginibus integris ciliatis vel glabris; cymæ paucifloræ terminales pedunculis pedicellisque filiformibus pubescentibus bracteis bracteolisque parvis acuminatis; sepala sublibera lanceolata acuta indistincte carinata dorso sparse pubescentia, 2·7 mm. longa; petala alba sublibera stellata oblongo-ovata acuminata, 4 mm. longa; filamenta filiformia antheris ovatis; carpella gracilia, stylis subulatis, squamis minutis.

Described from several living specimens.

Hab. Mountains near Queenstown on wet rocks, alt. 4000 ped. Leg. E. E. Galpin (no. 2021), Feb. & March, 1896.

This delicate species may be put amongst Harvey's section "*Petiolares.*" It seems to grow very much like *C. spathulata*, Thunb., but does not seem to branch so freely as this species. It has undoubtedly also close affinities with sect. "*Filipedes,*" and is probably nearly allied to *C. centauroides*, Linn., and *C. brachypetala*, E. Mey. From the former it can be at once distinguished by its petioled leaves; from the latter by its terete stem, shorter sepals, and other characters.

Crassula (§ Eucrassula) Simiana, *Schönland,* n. sp.—Perennis humilis ramosissima; rami ramulique tenues dense foliati, internodiis 3·5–4 mm. longis; folia carnosa applanata late obovata sessilia, 4–5 mm. longa; inflorescentiæ terminales subsessiles, cymosæ paucifloræ floribus pentameris vel tetrameris subsessilibus; sepala basi connata lobis crassis ovatis obtusis 0·33 mm. longis; petala sublibera ovata, 1·5 mm. longa; filamenta late linearia apice attenuata antheris late ovatis filamentis fere æquilongis; ovaria stylis fere æquilonga, styli late subulati, squamæ ovariis duplo breviores subrectangulares.

Described from living specimens which were received without flowers in May 1895, and flowered in Grahamstown, January 1896. Named in honour of its discoverer, Mr. T. R. Sim, F.L.S.

Hab. "Stormberg."

While the older leaves of this plant are perfectly glabrous, the upper part of the younger ones are covered with granular wax arranged in a reticulate manner (as in *Echeveria globosa*). In dry weather the leaves close together firmly, so that only their upper waxy part is exposed. In this way the young shoots are protected against excessive transpiration. In damp weather the leaves expand again. This plant grows somewhat after the manner of the *Seda gemina*, D. Koch *. The young shoots grow straight up to a height of between 3 and 5 cm. They then become top-heavy and fall down to the ground. Soon afterwards they root at the lower side and produce new shoots in the axils of those leaves which are pointing in an upward direction. Under favourable circumstances the same process is repeated by the new shoots, and thus large tufts may be formed.

Crassula Simiana is nearly allied to *C. dasyphylla*, Harv., which, however, has filiform pedicels and subsessile stigmata; whereas in the former the flowers are subsessile and a distinct style is present.

Crassula (§ Tillæa) Marlothii, *Schönland*, n. sp.—Annua (?) pumila; folia rosulata, omnia radicalia 10–15 mm. longa laminis obovatis vel orbicularibus in petiolum attenuatis; flores pentameri stellati ex axillis foliorum solitarii vel in cymis paucifloris, pedicelli tenuissimi 25–40 mm. longi, sepala ovata connata, petala rubra sublibera ovato-lanceolata acuminata, filamenta filiformia, antheræ ovatæ, carpella quatuor-ovulata, styli breves subulati, squamæ minutæ truncatæ.

Described from two dried specimens in Herb. Albany Museum. Named in honour of its discoverer, Dr. Rudolf Marloth of Capetown.

Hab. "In saxosis umbrosis montis 'Matroos,' prope Worcester," alt. 4500 ped. Leg. Dr. R. Marloth (no. 2202), Dec. 1895.

In habit this species reminds one of some species of *Tillæa*, Linn., its pentamerous flowers, combined with the occurrence of four ovules in each ovary, would place it amongst the genus

* See Engler und Prantl, 'Natürliche Pflanzenfamilien,' iii. 2te Abt. p. 30.

Crassula. In Engler and Prantl's 'Natürliche Pflanzenfamilien,' iii. 2te Abt. p. 37, I united *Tillæa*, Linn., *Bulliarda*, DC., *Helophytum*, Eckl. & Zeyh., and *Combesia*, A. Rich., with *Crassula*, and placed them all under the section *Tillæa*; and it seems to me that I was quite right in not considering the possession of tetramerous flowers to be of generic importance, especially as I have since found tetramerous flowers in a number of species of *Crassula*—e. g., they are of common occurrence in *C. spathulata*, Thunb., and *C. expansa*, Ait., and are the rule in *C. multicava*, Lem. (=*C. quadrifida*, Baker). Thus I have no hesitation in placing *C. Marlothii* also under the section *Tillæa* as defined in the 'Natürliche Pflanzenfamilien.'

Further Observations upon Assimilatory Inhibition. By ALFRED J. EWART, B.Sc., Ph.D.; 1851 Exhibition Scholar. (Communicated by Prof. R. J. HARVEY GIBSON, F.L.S.)

[Read 17th December, 1896.]

IN a previous paper an account has been given of the various modes in which an inhibition of assimilation may be induced experimentally. The following paper gives the effects of the continued absence of light or of CO_2 upon assimilation, which in the previous works were not mentioned.

The most obvious effect of the absence of light is that the chlorophyll grains do not become green but contain a yellow pigment, etiolin. Draper * in 1878 stated that etiolated plants in light can evolve oxygen; and Engelmann † found later, by means of the Bacterium method, that the etiolated leaves of seedlings of *Nasturtium* show a distinct power of assimilation. These results have not, however, been generally accepted as forming a complete proof that etiolin can take the place of chlorophyll as an assimilatory pigment, and have been by some botanists met with flat denial. Thus Timiriajeff ‡ objects entirely to the Bacterium method, as the absorption of heat-rays

* Draper, Scientific Memoirs, 1878.

† T. W. Engelmann, Bot. Zeitg. 1881, p. 445.

‡ C. Timiriajeff, "Sur la Fonction chlorophyllienne," Ann. Sci. Nat. 7 sér. ii. 1885, p. 99

alone by the chlorophyll grains will cause them to attract the Bacteria employed, and by inducing streaming currents in the surrounding fluid cause the Bacteria floating in it to move also. He concludes that Engelmann's observations of the evolution of oxygen (1) by etiolated cells, (2) by isolated chlorophyll grains, (3) the secondary maximum in the blue, are due to this error.

The objection is, however, quite unfounded. The physical movement of particles suspended in a fluid or streaming in one direction cannot possibly by even the most careless observer be confounded with the active and almost purposeful translatory movement of *B. Termo* in the presence of oxygen. The supposed error due to the absorption of heat-rays by the pigmented chlorophyll grains or coloured cell-contents, causing them to attract the Bacteria in the surrounding fluid, has conclusively been proved by Engelmann * to be non-existent.

The fact that isolated chlorophyll grains can assimilate and the presence of an assimilatory maximum in the blue can now, however, be regarded as well established.

The question as to whether the observations upon the presence of the power of assimilation in etiolated plants were correct or not seemed, however, worthy of further proof †. It is well known that in certain plants, even though developed in complete darkness, the leaves and chlorophyll grains become green. Such chlorophyll developed in darkness might not, however, be identical with that developed in light, and the chlorophyllaceous cells might possibly be at first, as regards the function of assimilation, in an etiolated condition, possessing at first only a weak power of assimilation or none at all. The following results obtained with *Pinus pinea* answer the above questions :—

* Engelmann, Bot. Zeitg. 1887, p. 107.

† The Bacterium method was employed as a test for the power of evolving oxygen in light. To the details given by Engelmann in the preceding paper it is only necessary to add that when *B. Termo* is cultivated upon Agar, for generation after generation, its vegetative vigour finally weakens, the motile condition lasts for a shorter and shorter time, and long non-motile Bacillus threads may be produced. On examination such cultures are found to be pure and really monotypic, but in the fresh cultures from isolation the threads soon reappear. In practice it is advisable to re-isolate the Bacterium (from the integuments of Peas, &c.) every month or so.

Pinus Pinea.—Seedlings developed in darkness at 20° C. to 22° C.

(*a*) Hypocotyl 4 cm., leaves 2·5 to 3 cm. long. Chlorophyll grains green but with slightly yellowish tinge. Oil drops in cell protoplasm. Preparations readily injured. Longitudinal sections through subdermal layers are best and show quite distinct but not strong power of assimilation.

(*b*) Leaves green, about 4 cm. long, bases pale. Chloroplastids have slight yellowish tinge and are paler than the same grains developed in light. Weak but distinct evolution of oxygen.

(*c*) Older plants. Cotyledonary leaves 6 cm. long, green but basal parts pale, protoplasm starved and attenuated. Apical tuft 2 cm. long; leaves—apical part pale green, basal part white. No evolution of O in light from either primary or secondary leaves. Brought into light the plants remain living for a few days and then mostly die without showing any return of the power of assimilation. A few remain living, the chlorophyll grains finally become deeper green and slightly larger, and show in 2 days a quite distinct power of assimilation, which in 3–4 days is fairly active.

The chloroplastids of *Pinus Pinea*, therefore, when developed in darkness are, though green, partially etiolated, and have a distinct but not strong power of assimilation, which later is lost.

For the experiments upon assimilation in etiolated plants seedlings from plants with large seeds were at first used. The following are the results:—

Helianthus annuus.—(1) Young plants: cotyledons deep yellow, cells filled with starch. No evolution of O perceptible. (2) Older plants, 20 cm. high; cotyledons 1·3 cm. long by ·8 cm. broad, dark yellow with but little starch; chloroplastids fairly large, distinct, and yellow; moderately active evolution of O. (3) Still older plants 20 cm. high; stem and young leaves quite pale and colourless; no evolution of O. Cotyledon 1·5 by ·9; chloroplastids fairly large, quite yellow; protoplasm clear and transparent; distinct but only weak evolution of O. (4) 5 days longer in darkness. No further growth. Cotyledons very slightly paler and chloroplastids slightly smaller. No evolution of O perceptible. In light the intact cotyledons and in many cases the attached lower halves of the cotyledons used for sections, if the cut surface is covered with vaseline, remain living, show in 2 to 3 days a faint evolution of O, and begin to turn green.

Cucurbita Pepo.—(1) Young plants: cotyledons deep yellow, cells filled with starch; no evolution of O perceptible. (2) 3 *days later*, deeper yellow, starch less in quantity; weak but distinct evolution of O. (3) 5 days later, very little starch; cotyledons dark yellow; chloroplastids fairly large, distinct, and quite yellow. Plant 20 cm. high, with cotyledons 2 cm. by 1, showing moderately active power of assimilation. (4) 5 days later, plant 24 cm., cotyledons 3·5 cm. by 1·5; 1st foliage leaf, lamina ·5 by ·8 cm., 2nd and stem 1·5 cm. long. 1st young foliage leaf is quite pale or faintly yellow and shows no evolution of O. Cotyledons, chloroplastids yellow, and somewhat smaller cells slightly starved; distinct but weak evolution of O. (5) 5 days later. Plants no larger, still more starved.

Cotyledons slightly paler, chlorophyll grains slightly smaller and almost unchanged, but no evolution of O. Plants with one cotyledon used for sections brought into light, the other cotyledons mostly after 2–3 days begin to turn green and show whilst still yellow (2nd day) a faint evolution of O, stronger on the 3rd day.

Phaseolus multiflorus.—Primary simple leaves, lamina 2·5 by 1·5 cm., and quite deep yellow, show a quite distinct but only weak evolution of O. The younger trifoliate leaves are from pale yellow to almost colourless, and show no perceptible evolution of O. In older plants the primary leaves are slightly paler, and assimilation is now absent or almost imperceptible. If the plant is now brought into light such leaves in some cases may recover, become green, and commence to assimilate, but in most cases slowly die.

It appears, therefore, that etiolated chlorophyll grains developed in perfect darkness may possess a weak power of assimilation. The preparations are made in weak light, at once placed in darkness until the Bacteria come to rest, then exposed to light and examined, the total exposure previous to examination being never more than a few minutes. Sections in closed cell preparations do not turn perceptibly green when exposed to light, however long they may remain living. To make absolutely certain that the evolution of oxygen was not perhaps due to the formation of traces of chlorophyll during the necessary few minutes' exposure, test preparations from adult etiolated cotyledons grown in perfect and continuous darkness were made in a photographic dark room in weak red lamp light and then at once examined as usual, when the same power of assimilation was shown as before.

Another possibility was that the etiolated cotyledons had perhaps the power of forming traces of chlorophyll, though not sufficient to make them perceptibly green, thereby being capable of showing weak assimilation.

Thus in a few of the *Helianthus* seedlings, though grown from the first in perfect darkness, the cotyledons are partially or almost entirely dark greenish on the outer surface. Microscopical examination of transverse sections shows that the chlorophyll grains of the outer epidermal layer, and in a few cases of the mesophyll layers immediately beneath, have a distinct greenish tinge. Living sections of such cotyledons examined by the Bacterium method show a stronger evolution of oxygen from the inner palisade parenchyma layer, which is always quite yellow, than from the outer spongy mesophyll layer, even though

the latter is more or less greenish. The green colour of the chlorophyll grains in such parts is not quite of the healthy normal shade.

The cotyledons of *Helianthus* have no power of turning green in darkness, nor is the apparent formation of chlorophyll due to a photo-inductive action of the previous exposure to light when in the dried condition. If a very large number of seeds are examined, a few especially of the larger ones are slightly darker and more greyish, instead of almost pure white as is normally the case. Sections of these examined in glycerine show a distinct though faint yellowish or greenish tinge to be present in the outer epidermal layers, and in some cases in a few or many cells of the mesophyll tissue immediately beneath. A slight amount of chlorophyll may therefore be formed in the outer layers of the colyledons of seeds of *Helianthus*, resembling the more complete formation which commonly takes place in the cotyledons of maple-seeds or orange-pips; but the chlorophyll in such green parts after developing in darkness for some time is neither as regards coloration or assimilation normal. In *Cucurbita*, in which the seeds are more completely shielded from light when developing, the cotyledons grown in darkness are always quite yellow.

Naturally for experimentation, and for the extraction and testing of the pigment, only pure yellow cotyledons of *Helianthus* are employed, and in addition the etiolated leaves or cotyledons of *Cucurbita Pepo*, *Lupinus albus*, *Zea Mays*, and *Phaseolus vulgaris*.

The leaves which have been grown in perfect darkness are dropped into water at 100° C or killed by ether or crushed in a mortar, brought into weak light, and after complete trituration extracted until a quite colourless residue is left. In *Helianthus* the cotyledons killed by hot water or ether are apt to become somewhat discoloured, in which case the extraction is continued until no more pigment can be dissolved *. Complete extraction with warm alcohol yields a perfectly yellow fluid, in which, by treatment with benzine, not the faintest trace of chlorophyll can be detected. If a large amount of water is added to the alcoholic solution, the benzine takes up all the etiolin and becomes a pure deep yellow. Treatment of the etiolated material with very

* The extraction is carried on in weak light or in darkness and in stoppered bottles.

dilute acid to obtain chlorophyllan, or with very dilute alkali to obtain alka-chlorophyll, gave in all cases negative results. If after the crushed etiolated cotyledons have been treated with dilute alkali, ether is added, the latter becomes pure yellow and leaves finally a perfectly colourless residue, thus proving the absence of all chlorophyll.

It is therefore in this case certain that etiolin can act as an assimilatory pigment, the assimilation being never more than moderately active, because the colour of the chloroplastids is much paler than when they are green, the etiolin being less abundant, and absorbing less light than chlorophyll does.

The quite young cotyledons are unable to assimilate owing to the fact that the cells are packed with starch and that the etiolated chlorophyll grains are not as yet fully developed. If the cotyledons are allowed to develop in light and turn green, they show a distinct power of assimilation at a much earlier stage and whilst much more starch is still present than when grown in darkness. In seedlings kept for a long time in darkness, the etiolated cotyledons finally lose the power of assimilation. This is in such cases partially a phenomenon of starvation, the etiolated chloroplastids becoming slightly smaller and paler, but is also due to the fact that chloroplastids when kept under conditions in which they are of necessity functionless (darkness, absence of CO_2) finally lose the power of assimilation. The longer the seedlings are kept in darkness or the older the individual leaves may be, the longer they take to turn green and regain their normal assimilatory powers when brought into the light. In seedlings this is undoubtedly partly due to the influence exercised upon the chloroplastids by the starvation to which they are finally subjected.

If seedlings of *Phaseolus multiflorus* are grown in darkness until further growth ceases, the largest plants have stems nearly 1 metre long, the basal simple leaves being 2 by 3 cm. and the petioles 5 to 7 cm., and 4 to 6 or more compound leaves, the largest lamina of which is not longer than 1 cm., being present. If such plants are brought into light, in some cases all the leaves die and the pale stem may remain living for as long as 2 weeks, but has no strength to bud out new leaves and finally dies. In some of the upper leaves the terminal leaflet remains yellow for as long as 3 weeks and then dies, the basal pair beginning to turn green in 1 week and in 2 are quite green. Certain of the

upper leaves not longer than $\frac{1}{2}$ to $\frac{2}{3}$ cm. may remain living for 1–2 weeks, but have lost the power of turning green. This is generally the case with the basal simple leaves in such plants.

If one of the cotyledons be removed from seedlings in which the plumule is but little developed, the plants remain small and the etiolated leaves retain their power of recovering and turning green in light as long as plants with both cotyledons do. If the young seedling has only one cotyledon, the deficient supply of nutriment causes the formation of a smaller plant, and the seedling is not starved any more rapidly than one with two cotyledons is. If, however, the seedling stems be a foot or so long when one cotyledon is removed, a marked difference is observed, although the plants do not increase nearly so much in length as seedlings with both cotyledons. The etiolated leaves on such plants lose the power of turning green when brought into light in from $\frac{2}{3}$ to $\frac{1}{2}$ the time that plants with both cotyledons do. If both cotyledons are removed the effect is still more quickly produced, but the entire plant in such cases is very apt to die.

Etiolated seedling plants (stems 12–15 cm.) of *Vicia Faba* gave similar results:—

(*a*) Cotyledons removed. Plants cease to grow. After 1 week in darkness at 25° C., then in light, remain living for several days, but the young yellow leaves do not turn green and the plant slowly dies.

(*b*) $\frac{2}{3}$ of cotyledons removed. Plants grow, but only slowly. After 2 weeks in darkness same as in (*a*).

(*c*) Cotyledons normal. After 2 weeks in darkness, then in light, all the leaves turn green, stems twice as long as in (*b*). After 4 weeks in darkness the power of recovering and turning green in the light is lost.

It is by no means always the case that etiolated parts show a power of evolving oxygen in light. Thus the secondary foliage-leaves of *Cucurbita* and *Helianthus* and the compound leaves of *Phaseolus*, developed in darkness on the seedlings, do not show any power of assimilation. This is here very evidently due to the lack of nourishment inhibiting or interfering with the formation of etiolin and the development of, and attainment of functional activity by, the chloroplastids.

In certain Gramineæ the leaves of seedling plants developed in darkness never attain any power of assimilation.

3 weeks' etiolated seedlings of *Hordeum distichum* and *Avena sativa*. Shoots yellow, chloroplastids pale yellow; no power of assimilation after 1 day in light at 15° C. (overcast January sky). Slight greenish tinge, and in parts very faint evolution of O. On 3rd day most leaves green, and show fairly to quite active evolution of O; few yellow or yellowish green, and show weak or no evolution of O.

Zea Mays.—Seedling from large corn. (*a*) Stem 25 cm. 1st leaf ·11 cm. and yellow, 4 cm. exposed and deep yellow. No evolution of O. After 14 hours' exposure to light leaves quite green, but evolution of O is only moderately active, later quite active. (*b*) Older plant with 1 nearly full-grown and 1 half-grown leaf. Both quite yellow, but no evolution of O. (*c*) Still older plant. Stem 40 cm. 1st leaf withered. 2nd leaf, apical half brown, basal part pale yellow and living; chloroplastids small, no assimilation. In light this half remains yellow and finally dies. 3rd leaf large, yellow and expanded. No assimilation. In light is greenish; on 3rd day shows weak evolution of O, fairly green and fairly active assimilation by 5th day. 4th leaf, partly enrolled and enclosing younger leaves, yellow slightly deeper, and chloroplastids slightly larger, but shows no assimilation. In light is in 1–2 days distinctly green and shows moderately active evolution of O. 5th leaf enclosed and yellowish, also shows no assimilation.

The inability of the etiolated chloroplastids in these plants to assimilate seems at first sight to be due to the small size of the seed and consequent deficiency of nutriment (sugar), causing a decreased formation of etiolin, or directly affecting the development of the assimilatory powers of the chloroplastids, especially as a slight power of assimilation might be present but be masked by the concomitant respiration. It is found, however, that equal weights of etiolated leaves of *Zea* and cotyledons of *Helianthus* and *Cucurbita* yield alcoholic extracts of etiolin of about the same relative strength; and microscopical examination of the etiolated chloroplastids detects no perceptible difference in either their form, condition, or depth of coloration sufficient to explain the presence of the power of assimilation in the one case and its absence in the other. Palladin * found that 10 days' etiolated leaves of seedling wheat contained plenty (0·85 gramme °/$_o$) of sugar; but on examining such leaves, and also those from 14 days' old plants, no power of assimilation can be detected. The etiolated seedling leaves of such grasses are unable in darkness to acquire the power of assimilation, not owing to any deficiency of nutriment or lack of etiolin, but as a direct effect of the absence of light, inhibiting the attainment by the chloroplastids of their normal functional activity.

* Palladin, "Ergrünen und Wachsthum der etiolirter Blätter," Ber. d. D. Bot. Gesell. ix. 1891, p. 229.

In another grass, *Phalaris canariensis*, though the seed is smaller and the store of nourishment is less than in the above cases, nevertheless in some of the young etiolated leaves a faint power of assimilation can be detected, and this is also the case with the cotyledons of etiolated seedlings from certain plants with oily and large or small seeds.

Phalaris canariensis.—(*a*) Stems 11–12 cm. long, reddish sheath (red sap) enclosing central yellow leaf, tip projecting for ½ to 1 cm., and showing very faint or no assimilation. After 1 day's exposure to light this leaf has turned green and shows fairly active evolution of O. (*b*) In plants larger than (*a*) the leaf-tip begins to wither and shows no assimilation.

Linum usitatissimum and *Brassica Napus.*—Cotyledons fairly deep yellow. (1) Cotyledons still packed with oil or starch. Evolution of O extremely faint or imperceptible. (2) Cotyledons, starch or oil much reduced, but a fair amount still present; weak but quite distinct evolution of O. (3) Later. Cotyledons starved, still yellow, but no assimilation.

Ricinus communis.—(*a*) Stem 25 cm. Cotyledons 3 by 2 cm., quite yellow oil-drops in cells but not many, show quite distinct but very weak evolution of O. (*b*) 5 days later cotyledons yellow and of same size, but no assimilation shown. In light are in 2 days fairly green and show moderately active assimilation.

Further experiments were performed with plants having bulbs or root-stocks containing a large store of nourishment, so that the plants could be kept living for months in continuous darkness.

Beta vulgaris.—(*a*) Etiolated leaves 10 cm. long, lamina 3 by 2 cm. Chloroplastids small and pale yellow; very weak but quite distinct evolution of O. (*b*) Leaf 15 cm., lamina 5 by 2 cm. Petiole and ribs reddish, lamina yellow, cells clear and transparent, chloroplastids small and pale yellow; very weak evolution of O. (*c*) Leaf 28 cm., lam. 5 by 2 cm., paler, and chloroplastids smaller and paler than when younger. No evolution of O. The best stock contains plenty of nourishment and on bringing the plants into light such leaves remain living, the lamina broadens and turns slowly green, and as it turns green commences to evolve O (distinct evolution of O in 3 days).

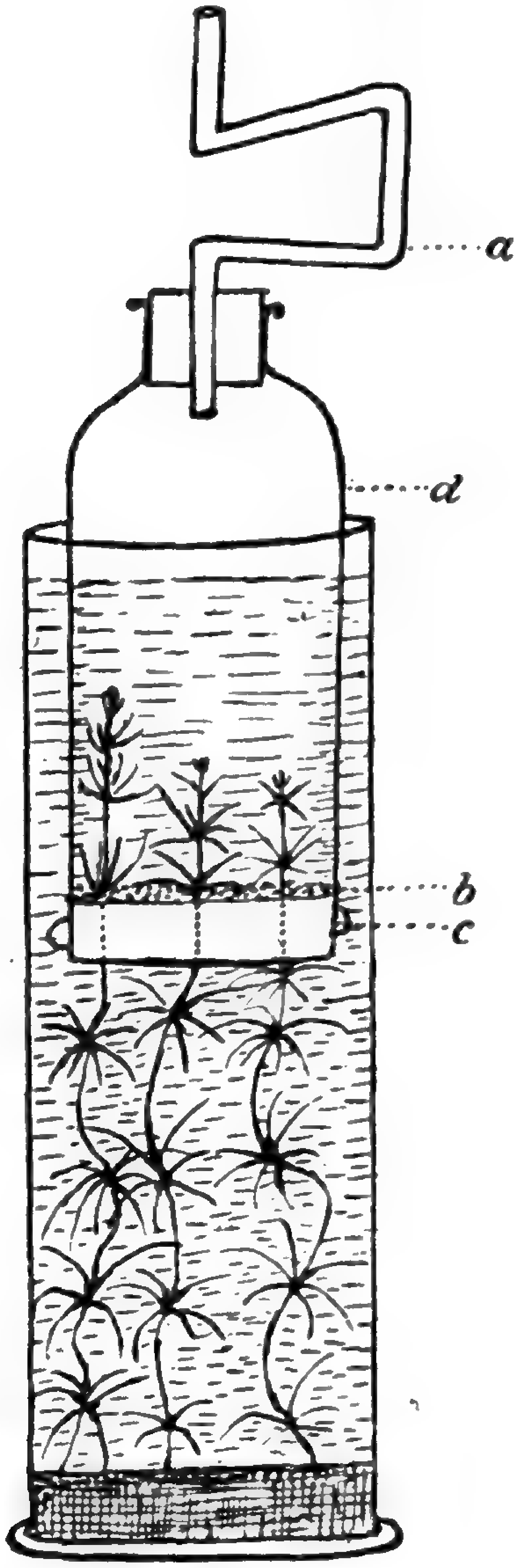
Hyacinthus.—(*a*) Leaves 15 cm. long, 2·5 broad, deep yellow at apex and edges, paler in middle and quite pale at base. Chloroplastids fairly large and yellow; distinct but very weak evolution of O. (*b*) 2 months later. Leaves 30 to 35 cm. long, lower half white, upper yellow, but showing no power of assimilation. In light the upper halves of the leaves take from 1–2 weeks to become thoroughly green and the basal parts are then still pale. After 1 week green to greenish-yellow parts show a moderately active evolution of O.

Allium Cepa.—Gives similar results to *Hyacinthus*, but the leaves do not live so long in darkness, are much branched and somewhat contorted, and the apical portions only are yellow.

Daucus Carota.—(*a*) Leaf 12 cm., laminal portion 1 cm., yellow not very deep. Entire thin leaflets examined, in apical parts colour is deeper, and here distinct but extremely weak evolution of O is shown, in rest imperceptible. (*b*) Leaves older and 15 cm. long, are yellow, but show no evolution of O.

Brassica Napus.—Leaf 23 cm., terminal leaflet 3·5 by 1 cm., largest lateral leaflet 2 by 1 cm. Chloroplastids pale yellow. Colour deepest in the imperfectly differentiated palisade parenchyma layers. Here a distinct but rather weak evolution of O is shown (stronger than in any of the other foliage-leaves examined). From the other etiolated assimilatory cells and tissues a distinct but much weaker evolution of O.

Apium graveolens.—(*a*) Young leaf 5 cm., leaflets pale yellow; no assimilation perceptible. (*b*) Leaf 8 cm., in parts yellow colour is deeper; here a just perceptible trace of assimilation is shown, in rest none.



a. Open bent glass tube painted black inside and out.

b. Layer of coarse emery powder.

c. Cork, through which the *Chara* stems pass.

d. Painted and opaque glass cylinder, in the figure drawn as if transparent.

Experiments were also made with two water-plants, namely *Chara* and *Elodea*. If entire plants of *Chara* are kept in darkness, they die without becoming at all etiolated. If, however, the apices of strong shoots are allowed to grow into perfectly dark cylinders (see fig., p. 563), they may remain living for a considerable time.

The following are the results thus obtained :—

Chara fragilis.—(*a*) After 3 weeks, the plants have three internodes in darkness normal in appearance, quite green, but paler and more transparent than the lower parts exposed to light. The paleness is partly due to the youth and absence of all deposit from the parts formed in darkness. On examination, the lowest branches show fairly active assimilation, the upper branches moderately active. (*b*) After 5 weeks the parts in darkness have increased but little in size, are green but paler than normal, and show moderately active evolution of O, which in some of the upper young branches is very weak or imperceptible. Longest stem is 5 cm. (3 internodes and apical tuft). (*c*) After 8 weeks all the parts in darkness are dead.

Hence the filaments in darkness are not supplied with sufficient food, and slowly starve. Growth becomes slower and slower and finally ceases, the chlorophyll pigment is formed in smaller quantity than normal, but no true etiolation is produced. In darkness *Chara* can produce normal green chloroplastids capable of fairly active assimilation. It is possible that if the supply of food-material were sufficient, the growth of the plant and production of new chlorophyll might go on indefinitely. *Chara* therefore in this respect resembles *Pinus* and other conifers, for here, also in the seedlings, the cotyledons become green in darkness, but the secondary leaves remain quite pale owing to the supply of food-material being insufficient in quantity to permit of the formation of the chlorophyll pigment and proper development of the chloroplastids.

The changes undergone by the chlorophyll grains of *Elodea* when kept in darkness in water have been previously described. Even if the apices of vigorous shoots are led into and allowed to develop in dark chambers, it is very difficult to obtain etiolated specimens with otherwise normal chlorophyll grains, for, owing to the parts in darkness being subjected to partial starvation, the chlorophyll grains remain small, may be almost colourless, and such leaves developed in darkness show no power of assimilation. In November, under the mud on which the plant grows

the horizontal branching stems remain living, and from them short condensed colourless or pale yellow shoots arise, the cells of which are packed with starch grains. These, if the weather be favourable and warm, grow and emerge above the surface of the mud and then become slowly green; but the leaves are small, packed with starch grains, and show only a weak power of assimilation, which, where the starch is especially abundant or the green coloration only slight, is imperceptible. When the winter frosts commence all the parts above ground are killed, only the underground part of the stem and the attached etiolated amyliferous winter shoots buried in mud can survive the winter and recommence growth next spring *. The amyliferous leaf-cells seem to contain no chloroplastids; the mass of starch grains with which the cell is filled may either be colourless or have a distinctly yellowish or occasionally brownish tinge. Close examination shows that each starch grain or group of starch grains is imbedded in a matrix, which is really the body of an amyloplast and with it forms a thin brown film enclosing the blue starch grain.

Etiolated shoots brought to a temp. of 20° C. and exposed to light begin to elongate distinctly in a day or two, the starch grains to disappear, and the chloroplastids to become distinctly visible. After 3 days the chloroplastids are still pale yellowish green, and assimilation is weak or imperceptible. After 5 days the starch grains are very much reduced in size, and in many chloroplastids have disappeared. The latter are still not so deeply green as normal, assimilation in a few leaves is fairly active, in most is weak, and in a few still imperceptible. In all cases the amyloplast finally loses its starch owing to the growth of the leaf using up more plastic material than is supplied by the still weak assimilation, and becomes a normal chloroplastid. No destruction or disappearance of "primary amyliferous chlorophyll grains" followed by a new formation by plasmatic differentiation of "secondary normal assimilatory chlorophyll grains" takes place.

Apparently in the etiolated condition the leaves of *Elodea* have no power of assimilation, this becoming perceptible only when the chlorophyll grains are distinctly greenish. The

* Herein lies the explanation of the fact that *Elodea*, though all vegetative parts are killed by being frozen, and though it neither fruits nor forms special resistant propagula or bulbils, can nevertheless survive in Northern Europe, year after year, during even severe winters.

presence of an excess of starch, and the fact that the leaves are young and not adult, act as factors delaying the commencement of assimilation on exposure to light and rendering it uncertain whether under more favourable conditions the etiolated leaves might not be capable of weak assimilation. To eliminate these errors, plants with amyliferous etiolated shoots were kept in well oxygenated water in darkness at 20° C. for 10 days or at 30° C. for 7 days, and then examined and exposed to light.

Elodea canadensis.—Shoots elongated, leaves larger; starch grains much reduced in quantity and size, in parts almost none; chloroplastids colourless to pale yellow, but no power of assimilation. After 8 hours' exposure to light the colour is deeper, but still no evolution of O; at end of 2nd day, chloroplastids yellowish to pale yellowish green: from latter a weak evolution of O, from former none. At end of 3rd day leaves green to greenish yellow and weak to moderately active evolution of O.

If closed-ringed cell preparations of etiolated leaves of *Elodea* are exposed to light in no case do they turn green, nor if they already have been exposed long enough to possess a slight greenish tinge does the green coloration deepen in the closed cell. Such preparations may remain living for days, and in some cases a few of the cells may, if the ringing be thin or if the leaves are slightly greenish, show protoplasmic streaming. Correns * has shown that for etiolated plants to turn green a given pressure of oxygen, varying from 30 to 60 mm. hydrogen pressure, is required; whilst Clark † found that streaming in cells commences at an oxygen pressure of from 1·2 mm. to 2·8 mm. hydrogen pressure. In the etiolated leaves of *Elodea* also, under the above conditions, a partial pressure of oxygen which is sufficient to permit of slow rotation is insufficient to allow the chlorophyll grains to turn green, especially as the accumulation of the respiratory CO_2 also exercises an inhibitory influence upon the turning green of etiolated leaves ‡.

If etiolated leaves are placed in a plasmolytic (20°/₀) solution of cane-sugar and exposed to light at 20° C. to 25° C., after 3 days many leaves are distinctly greenish or yellowish green.

* C. Correns, in Flora, 1892, p. 141.

† J. Clark, in Ber. d. D. Bot. Gesell. vi. 1888, p. 273.

‡ J. Boehm, "Ueber den Einfluss der Kohlensaure auf das Ergrünen und Wachsthum der Pflanzen" (Sitzungsber. d. k. Akad. d. Wiss. Wien, Bd. lxviii. July 1873), found that cress seedlings in 20 °/₀ CO_2 do not turn green, but that in 50 °/₀ in the presence of O, exposed to light, grasses still turn slightly green.

Many cells have by the plasmolysis been separated into two halves, a nucleated and a non-nucleated, and the chlorophyll bodies of both of these may in many cases be seen to be equally green. The green coloration of the chloroplastids of the non-nucleated half is especially well brought out, when, as is often the case in sugar solution, the cells form a purple-red sap which may be quite deep in colour. Apparently the chlorophyll grains may turn green without a nucleus being in organic connexion with them, for between the two protoplasts no filamentous or other protoplasmic connexions can be seen in many cases in which the grains have become distinctly green. It is possible, however, that such connexions through which the nuclear influence can be transmitted might have at first existed and later become broken off, for no further deepening of colour takes place, but instead the chlorophyll grains begin to alter and show degenerative changes. These take place much more rapidly in the non-nucleated portions, the chlorophyll grains here becoming finally quite small and colourless, and also, but much more slowly, in the nucleated portions, here becoming also smaller but acquiring a brownish coloration. If non-nucleated portions are separated by cutting open the cell to which they belong and kept in a hanging drop of sugar solution exposed to light, though they may remain living for a day, in all cases they die and decolorize without having acquired any perceptible greenish tinge. In a plasmolytic solution of KNO_3 the leaves do not turn at all green, but remain quite pale or yellow until they die.

Experiments tried by placing sections of etiolated leaves of *Phaseolus*, *Hordeum*, and *Avena* and *Cucurbita* in plasmolytic sugar solution exposed to light failed, the sections under these conditions refusing to turn in the least green, though in many cases they were kept alive under examination for 3 days and more. Apparently the withdrawal of water by plasmolysis delays in all cases, and commonly inhibits, the turning green of etiolated chloroplastids.

Assimilatory Inhibition in CO_2*-free atmosphere.*

Vochting * has shown that if exposed to light in an atmosphere free of all CO_2, leaves of *Mimosa* soon die and potato-leaves turn bluish green, show abnormal twistings and curvatures, and finally

* Vochting, "Ueber die Abhangigkeit des Laubblattes von seiner Assimilations-Thatigkeit," Bot. Zeitg. 1891, pp. 113 & 129.

also die in a longer but also relatively very short time. Vochting concludes that the leaves lose the power of assimilation—an assumption which is not justifiable without direct experimental evidence for the same being given, and which leaves the questions as to whether the loss of the power of assimilation precedes or is concomitant with death, and whether, if the former be the case, recovery is possible, unanswered.

Mimosa does not form very favourable material for experimentation in this direction, as the leaves are very sensitive and are very readily fatally injured, but with potatoes very good results were obtained.

Direct observation shows that the leaves formed on the etiolated shoots of potatoes grown in darkness are yellowish, very small, and show no power of assimilation. Exceptionally leaves nearly 2 cm. long with a terminal leaflet 0·5 to 0·8 cm. long may be found, but generally the leaves are very much smaller than this. If such etiolated shoots are exposed to light in an atmosphere kept free from CO_2, the leaves grow slightly and turn green, but soon become bluish green and do not become longer than 1 cm. in length, then turning yellow and slowly dying. The chlorophyll grains of leaves which have turned green under these conditions are normal in shape and deep green or bluish green in colour, but the leaves show only a weak power of assimilation, which in a few cases is in parts fairly active. The power of assimilation often varies in different parts of the same leaf, being in parts weak and in parts imperceptible. Many quite green leaves of various sizes (0·3, 0·4, 0·5, and 0·8 cm. long) show no perceptible power of assimilation. A portion of the leaf is examined and the rest left attached, the cut surface being covered with vaseline. Such leaves, on the plant being exposed to normal CO_2 containing air, frequently die, but may recover, resume growth, and finally show active assimilation. It is probably often the injury which causes the death of the leaf and prevents recovery. Leaves with even a slight yellowish tinge show no power of assimilation or recovery.

The stem also turns green. In the younger parts of the stem the outer cortex has well-defined fairly dark-green chlorophyll grains, but has no power of assimilation. In the inner cortex a faint power of assimilation may be present. In the central parenchyma the colour is much fainter, the chlorophyll grains are less well defined and in some cases almost undifferentiated; but

a quite distinct and from weak to moderately active power of assimilation is shown. In the older basal parts of the stem in both cortex and pith the chlorophyll grains are more or less undifferentiated, the cells in some cases containing irregularly shaped grains or almost completely diffuse green contents, and in others normal round pale-green grains. The amount of chlorophyll is less relatively to the size of the cells in the older than in the younger stems. In the outer cortex no evolution of oxygen is shown; but in the inner cortex and pith a very weak but distinct evolution is shown, whether the chlorophyll grains are more or less diffuse, or are definite *. If such stems are now exposed to light in ordinary air and examined after a week, in the cortex the chloroplastids are green, fairly large, normal, round, may contain starch grains and show a fairly active power of assimilation; in the pith the chlorophyll grains are fewer but normal, round, green, and show a rather weak evolution of oxygen, which is, however, normal for the relative amount of chlorophyll present.

The reason why in the above cases the power of assimilation disappears in the cortex but remains in the pith is because in the latter case traces of CO_2 derived from the respiration of the surrounding parts, and perhaps also directly through the stem from the roots along with the transpiration-current, are present and can be assimilated; whereas in the outex cortex this is not the case, and the chlorophyll grains, exposed to light but unable to assimilate owing to the absence of all free CO_2, fall ill and lose, at first temporarily but finally permanently, the power of assimilation.

That the constant presence of the merest trace of CO_2 is sufficient to prevent the loss of the power of assimilation from taking place, is shown by the following experiment. A pot containing a large potato with a number of etiolated shoots is placed in a hermetically sealed bell-jar along with several vessels of KHO solution placed at different levels in the bell-jar, so that only a very small trace of the CO_2 evolved from the tuber and roots escapes absorption and reaches the leaves. Nevertheless,

* Diffuse chlorophyll in cells capable of assimilation, though rare in Phanerogams, is present normally in parts of *Cuscuta* and in epidermal hairs of *Orobanche*. The above is, however, interesting as being a case in which a cell which normally has definite chlorophyll grains may have diffuse chlorophyll and yet be capable of assimilation.

the leaves grow quite large in a few days, becoming finally of almost normal size, remain normal in colour, and possess an active power of assimilation. The trace of CO_2 here present and assimilated exercises a kind of medicinal tonic effect, the main growth of the leaf being due to the supply of plastic material from the reserve stores in the tuber, the plant, as a whole, losing in weight.

Experiments with other tuberous plants gave similar results:—

Hyacinth.—In darkness at 20° C. to 25° C. for two months. Leaves 12–14 cm. long, in smaller side-shoot 4 to 5 cm. Larger shoot in CO_2-free air exposed to light. In 4 days is fairly green, in 1 week is fully green (side-shoot in air is in 4–5 days quite green, more rapid because younger). Chloroplastids in both after 1 week normal green, and show an active evolution of oxygen, about equal in the two cases. After 3 weeks the shoot in CO_2-free air shows in parts a yellowish tinge and, on examination, no evolution of O; but in one leaf a faint power of assimilation is still present. On returning to normal air this leaf and a few others remain living and recover; the rest turn yellow and slowly die.

Turnip.—Etiolated leaves 5–12 cm. long, exposed to light in CO_2-free air. By 2nd day are green to yellowish green, and show, on examination, an active evolution of O. Leaves, outside in air, of same age turn green at the same rate; but young leaves 4–5 cm. long turn green quicker than older ones 10–15 cm. long. After 4 days leaves inside 12–15 cm. long begin to turn yellow, and show no evolution of O. After 1 week younger leaves 5–8 cm. long are also yellow to yellowish green, and all show no evolution of O. On escaping to normal air all the yellowish leaves die. If after 4 days they are exposed to normal air, almost without exception all the leaves recover and show active assimilation, though some of the older leaves at first showed no power of evolving O.

Beet-root.—Etiolated leaves in CO_2-free air. In 2 days yellowish, and in 2–3 days fairly green (about as rapidly as in air); but a slight yellowish tinge remains. Fairly active evolution of O. Lamina grows and broadens perceptibly after 4 days, but remains thin and imperfectly expanded. At end of 15 days are from 5 by 2 cm. to 4 by 1·5 cm. Older leaves begin to twist and curl, are slightly yellowish green, and show no assimilation. Young leaves very slight yellowish or brownish tinge; assimilation very weak or absent. On exposure to normal air nearly all the leaves remain living, lamina broadens, increases, turns deep green, and shows active assimilation; but in some of the older leaves the lamina in parts or almost entirely withers and dies.

The foregoing results show clearly that an etiolated leaf can turn green and acquire an active power of assimilation if exposed to light in an atmosphere free from CO_2 in which the chloroplastids are prevented from assimilating. Sooner or later, according to the specific nature of the plant experimented with, the assimilatory powers begin to decrease and finally cease. The cessation may take place when the chloroplastids are, to all out-

ward appearances, quite normal and green, when, if the exposure has not been too prolonged, perfect recovery may, as a general rule, take place. Finally, the chlorophyll turns yellow or brownish; and when this has taken place recovery is for the most part no longer possible.

The different power of resistance which the leaves of different plants show is primarily due to the hereditary nature of each given plant, but is also dependent upon the age, condition, and morphological character of the leaf, the supply of food-material, and the readiness with which the latter is available for the nutrition of the former. Fleshy leaves, such as those of the Hyacinth, are more resistant than more thin and membranous leaves. This is probably owing to the fact that traces of CO_2 may reach the assimilatory cells from the more or less non-chlorophyllaceous inner tissues of such leaves, and perhaps by longitudinal conduction also along with the transpiration-current from the underground parts. Hence very fleshy plants (Cactaceæ, Crassulaceæ) are probably extremely resistant in this direction, especially bearing in mind Meyer's * observations that such plants can evolve oxygen and hence assimilate in the absence of CO_2, if exposed to light, by the decomposition of certain organic acids commonly present and formed abundantly in darkness. Leaves which remain small when grown in darkness are the most sensitive to exposure to light in an atmosphere free of CO_2. The reason is that the growth, attainment of functional activity, and maintenance of the same in such leaves is much more closely dependent upon their assimilatory activity than it is in leaves which can attain their full normal size in darkness. A full account of this question is given by Jost †.

That the phenomena above described are not due to the prevention of assimilation by the absence of CO_2 causing the leaf to be starved, has already been clearly shown by Vochting (*l. c.*) and Jost (*l. c.*). In the following experiments, however, with seedlings the effects of starvation and of the prevention of assimilation work conjointly.

* Meyer, 'Landwirth. Versuchsst.' 1875, Bd. xviii. p. 410, 1878, Bd. xxi. p. 277; and 'Die Sauerstoffanscheidung fleischiger Pflanzen,' 1876; and also Aubert, "Recherches sur la Respiration et l'Assimilation des Plantes grasses," Revue générale de Botanique, 1892, pp. 421 & 558.

† Ludwig Jost, "Ueber die Abhangigkeit des Laubblattes von seiner Assimilations-Thatigkeit," Pringsh. Jahrb. xxvii. 1897, p. 403.

Helianthus annuus.—Young seedlings with etiolated cotyledons in CO_2-free air turn in 1 day quite green (as rapidly as in normal air), and show quite active assimilation. (*a*) After 7 days—plant, cotyledons 2 by 1·2 cm., quite green, and shows rather weak but distinct evolution of O. (*b*) After 11 days—plant, cotyledons 2·5 by 1 cm., faint yellowish tinge, no evolution of O; 1st pair of leaves 1·5 by ·7 cm., yellowish, and no evolution of O. In air the tips of these leaves and tip of cotyledon die; rest remain living, recover, and show active assimilation. (*c*) Cotyledons 2 by 1·2 cm., 1st leaves 0·6 by 0·3 cm., yellowish tinge almost imperceptible. No evolution of O or (*d*) faint trace of assimilation in parts of cotyledons, none in 1st leaf. In air both (*c*) and (*d*) recover and resume growth. Etiolated seedlings of the same age kept for the same time in darkness almost all turn green, and remain living when brought into light.

Cucurbita Pepo.—Seedlings. In 1 day the cotyledons are quite green and show an active evolution of O. (*a*) After 5 days cotyledons 6 by 2·5 cm., and still green, show weak to moderately active evolution of O. 1st young leaf (lamina 1·3 by 1 cm.) green, but apex yellowish; faint evolution of O at base only. Such a plant in air recovers entirely, and shows in 2–3 days active assimilation in cotyledons and 1st leaf. (*b*) After 10 days, cotyledons in parts slightly brownish or yellowish green; no evolution of O. In air plants recover, and in 2–3 days show active assimilation. (*c*) After 13 days, cotyledons yellowish over greater part. No evolution of O. In 2 days in air part of 1 cotyledon remains green and shows weak assimilation, but in 3–4 days entire plant dies. Similar plants kept in darkness for the same time nearly all turn green and remain living in light.

Etiolated seedlings, therefore, in darkness remain living for a longer time than if exposed to light, but are prevented from assimilating by the removal of all CO_2. When the plant is exposed to light and turns green, the inability to assimilate exercises a more injurious influence upon the chloroplastids, and hence finally upon the entire plant, than if they remained etiolated in darkness.

If green parts developed in light are prevented from exercising their normal functional activity by being kept in darkness, they also finally lose their power of assimilation. In certain cases this takes place with considerable rapidity. Thus, leaves of *Phaseolus*, after being for two weeks in darkness, are quite yellowish and can no longer assimilate. The same takes place, as we have seen, even in such plants as *Pinus sylvestris*, which can form chlorophyll in darkness, but is here partly a result of the starvation to which the seedling plants experimented with are finally subjected. Similar phenomena, the details of which have been previously given, are shown by *Pellionia Daveanana* when the entire plants are kept for some time in darkness. Here also, however, the chloroplastids, partially at any rate, lose the power of assimilation, owing to the changes induced

in them by starvation, as well as by the absence of light. Green leaves of ***Elodea canadensis*** kept in darkness in weak sugar solution remain green, and may retain the power of assimilation for weeks. Finally, it begins to weaken, and after 2–3 months, though in many parts green and apparently normal chlorophyll grains may be found, in no case can any power of assimilation be detected. Such parts, however, may, on re-accustoming to water, remain living, and finally resume their normal function. In this case the loss of the power of assimilation cannot be a phenomenon of starvation, but is probably directly due to the enforced continual functional inactivity of the chloroplastid, finally inducing in it a condition characterized by a temporary or permanent inability to assimilate.

Conclusions.

Chloroplastids developed in darkness, whether they become green or are etiolated, may possess a fairly active power of assimilation corresponding to their size and depth of coloration. The power of assimilation is absent whilst the etiolated leaf is still quite young, and finally disappears again after the leaf has been kept for a long time in darkness, even though abundant supplies of food-material may be present. Etiolated leaves exposed to light in an atmosphere deprived of all CO_2 turn green, and may acquire a quite active power of assimilation, which, however, soon begins to weaken and is in most cases rapidly lost. The stoppage of assimilation may take place whilst the chloroplastids are still normal in appearance; but in all cases a visible change in appearance and coloration is finally produced. From the first condition recovery is generally, but from the second only rarely, possible. Assimilatory cells or tissues, therefore, which are prevented from assimilating by being kept in darkness, or by being exposed to light in an atmosphere deprived of all CO_2, retain their potential power of assimilation only for a given length of time, which is, the other conditions being similar, shorter in the latter case than in the former, and which is in each case mainly dependent upon the hereditary nature of the given plant.

Note on the Effects of Exposure to Sunlight upon Chara.

My attention has been called by Prof. Pfeffer to certain peculiarities exhibited by a culture of *Chara hispida,* Linn., which during July and August 1895 was accidentally exposed in a

window facing east to intermittent direct sunlight. As a result, the plants in a few days turned quite pale or white, and appeared to be dead. In this condition they remained exposed in a window facing north to diffuse daylight until, in spring 1896, they began to show signs of life and new growth. Examined in June 1896, the different parts varied, from white, pale green, yellowish or brownish green, to quite green in the young renovating parts. The latter are normal and show active assimilation. The older, perfectly white stems are dead and the cortical cells frequently come loose in loops, owing to the stem untwisting in such regions when the longer cortical cells come free from the shorter medullary cell. Such parts are dead. In many parts which, to the naked eye, appear white or only extremely faintly greenish, on examination the cells are found to be living and showing rotation. The chlorophyll grains have been killed and form separate irregular, colourless, faintly transparent polyhedral grains massed together, frequently in bands with clear spaces between, but in other cases entirely covering the inner surface of the cell-wall.

Careful examination shows normal green, often brownish-green chlorophyll grains to be present between or generally within these. All conditions may be seen, from cells which contain $\frac{1}{2}$ to $\frac{1}{3}$ their normal amount of chlorophyll grains to ones in which only occasional scattered and pale or brownish-green chlorophyll grains are present, and the quantity of chlorophyll is less than $\frac{1}{20}$ or $\frac{1}{30}$ to $\frac{1}{40}$ of the normal amount. The former cells show a fairly active evolution of oxygen, which in the latter is quite weak or faint, and can be seen to radiate from where the normal living chlorophyll grains are present. These phenomena are shown best by the whorled leaflets from 0·5 to 1 cm. long, composed of 3 to 6 naked cells. The chlorophyll grains may form irregular masses containing several small starch grains, or may form short straight constricted chains of 4 to 8 chlorophyll grains joined together. In many of the living end-cells the chlorophyll is present almost entirely in this latter form, and is extremely scarce, the chlorophyll grains, chains, or masses being separated by extremely large intervening clear spaces, and this although few or dead chlorophyll grains are present. Such cells show a weak but distinct evolution of oxygen, even though, as is often the case, the chlorophyll grains are brownish green in colour. No living cells entirely without living chlorophyll grains were found,

though such undoubtedly originally existed, and may have, as has been previously shown, remained living for more than a week. Several cells were, however, seen in which scattered green chlorophyll grains were present at one end only, at the other only dead colourless chlorophyll grains being present, this part showing absolutely no evolution of oxygen, the other weak or very faint.

The dead chlorophyll grains remain in the ectoplasm and do not leave the wall, as was the case in the experiments mentioned by Pringsheim, in which by means of sunlight he killed the chlorophyll grains over small exposed areas of cells of *Chara* and *Nitella*. It is commonly only where a large number are living that green chloroplastids are found interpolated between the dead colourless ones. The reason why no internal regeneration and proliferation of the chlorophyll bodies takes place is because the cells were, when exposed, fairly adult. In the younger parts, which remain living and capable of growth, renovation does take place and normal green parts are finally produced.

Where less than $\frac{1}{15}$ or so of the original amount of chlorophyll is present, supposing that in *Chara* there is a somewhat similar relation between respiration and assimilation as there is in Phanerogams, where an assimilatory tissue such as a leaf can assimilate, under the most favourable conditions, from 20 to 30 times the amount of CO_2 that it can respire in the same time, then this amount of chlorophyll will, especially bearing in mind the fact that under normal conditions during half the time the plants are in darkness, be unable to assimilate sufficient carbon to compensate for the amount lost by respiration, and partial starvation must ensue until the quantity of plasma is reduced to an amount corresponding with the lessened amount of chlorophyll present. This is actually the case, for in such cells the endoplasma is much thinned and consequently the rotation in it also difficult to observe; whilst the ectoplasm, containing as it does from $\frac{1}{3}$ to $\frac{1}{2}$ its bulk of dead chlorophyll grains, is also lessened in amount. That the ectoplasm surrounding the dead chloroplastids remains living is shown by the fact that signs indicating a distinct growth and elongation of the cell-wall subsequent to the killing of the original chlorophyll layer can frequently be noticed. The chlorophyll grains found present in such cells are ones which have escaped the fate which befell their brethren owing to their accidentally being protected by being

within the outer chlorophyll layer, either fixed or at first swimming with the rotation-current, and, when the crisis was over, becoming fixed again. These chlorophyll grains are always underneath the dead chlorophyll layer. That they possess a fairly active power of assimilation is shown by the fact that they commonly contain small starch grains as well as by the amount of oxygen they can evolve.

The phenomena above described, and more especially the fact that cells in which all the chloroplastids, with the exception of a very few which accidentally escaped and which were barely able to provide sufficient assimilatory material for the subsistence of the cell, could nevertheless remain living, though incapable of regenerating fresh chlorophyll, for a period of a year, forms an excellent illustration of the relative independence of chloroplastid and cell-plasma, and of the much greater sensitivity of the former to the action of sunlight.

On the Development of the Ovule of *Christisonia*, a Genus of the *Orobanchaceæ*. By W. C. Worsdell. (Communicated by Prof. J. B. Farmer, M.A., F.L.S.)

[Read 17th December, 1896.]

(Plates XX.–XXII.)

Having at my disposal material of three species of *Christisonia*, whose vegetative structures I described in a former paper*, I was able, by the aid of microtome-sections, to study the embryological development of these plants from the earliest stage to that of the mature seed.

L. Koch †, in his work on *Orobanche*, has described, in the fullest detail, the development of the ovule in that plant. From my own observations on *Christisonia* it would appear that the latter plant is essentially similar to *Orobanche* in this respect; so that I have in this contribution nothing really new to bring forward on this subject. At the same time, from the fact that *Christisonia* in its general habit and vegetative structure presents important

* "On the Comparative Anatomy of certain Species of the Genus *Christisonia*," Ann. Bot. vol. ix. 1895.

† 'Die Entwickelungsgeschichte der Orobanchen,' 1887.

differences from *Orobanche*, it is interesting to show the homogeneity which exists in the reproductive organs of the two genera.

Hofmeister*, in 1859, described the structure of the embryo-sac of *Lathræa squamaria* at certain stages of its development, but did not offer much detail on the subject.

During the course of my work I have had considerable obstacles to put up with in the character of the ovules in this plant. Their small size, their disposition on the placenta, and the deep purple coloration which, in the two species of which there was plentiful material, disfigured the whole plant, rendered the determination and position of the nuclei in the various parts of the ovule a by no means easy task.

Structure of the Ovary.

As stated in my former paper, the ovary of *Christisonia* is unilocular, with two bipartite placentas. In one of the species (*C. neilgherrica*, Gardn.), however, there is a slight modification, the lower portion of the ovary being bilocular owing to the fact that the placentas from opposite sides meet and fuse in the centre, whereby the ovules acquire an axile placentation; in the upper part of the ovary the placentas again separate, and the ovary becomes unilocular. The ovary of *Orobanche* differs from the plant under consideration in having four or five simple placentas.

The ovule is *anatropous* in form, and is attached to the placenta by a rather long funicle, so that it does not lie perfectly horizontal in the ovary, but takes up a more or less oblique position. Its *single* integument consists of two layers, of which the outermost has very much larger cells than those of the inner layer, which latter in the mature seed becomes no longer recognizable as such. The cells of the outer layer of the integument, which eventually forms the testa of the seed, are characterized, as in *Orobanche*, by having excessively thickened inner and lateral walls, which are lignified. The inner walls, viz. those bordering on the inner layer of the integument, have curious wide pits at intervals, which give them quite a characteristic appearance. The nucellus is two or three layers of cells in thickness.

* 'Neue Beiträge z. Kenntniss d. Embryobildung d. Phanerogamen,' 1859.

Development of the Ovule.

At the earliest stage in the development, the young ovule appears as a papilla produced by local divisions in the cells of the outer layers of the placenta. Occasionally twin-ovules are seen developing together where ordinarily but one would occur. In the papilla the *archesporium* is first differentiated from a group of elements as an enlarging hypodermal cell with dense protoplasmic contents and a large conspicuous nucleus (Pl. XX. fig. 1, *ar*). Two such cells may sometimes develop for a time together; but finally one only persists, the other becoming crushed (figs. 3, 8). Limiting the archesporium on the outside is an arc of smaller cells subsequently constituting a portion of the nucellus (figs. 1–3, 5, 7, 8). Owing to division of the cells on the inner side of the archesporium, the ovule becomes pushed outward and increases in length and breadth, the cells of the protective arc on the outside at the same time dividing longitudinally. Very soon, as a result of the quicker growth of the cells on one side, the ovule bends over towards the opposite side, its apex being, at this period, directed parallel to the surface of the placenta (fig. 2). At this stage the walls of two or three of the outer cells on either side of the ovule, behind the apex, begin to bulge outward, this being the first indication of the differentiation of the integument. As the archesporium grows in length, divisions occur in the cells just mentioned, as also in some of those behind them, such that the nucellus and the integument become differentiated, the former remaining a single layer round the apex of the archesporium, but of more than one layer farther on the inside. The integument eventually becomes two layers thick. The apex of the ovule at length becomes directed perpendicularly to the surface of the placenta, assuming its mature anatropous position.

In the further development of the archesporial cell no tapetal cells were seen to be cut off, such as occur in the majority of Dicotyledonous plants.

This cell shortly afterwards becomes divided into two equivalent cells by a transverse wall (figs. 4, 5). Each of these cells then divides again, so that a row of four cells is the result (fig. 6). Of these the hindermost, *i. e.* the cell farthest away from the apex of the ovule, alone increases in size, and gradually crushes and absorbs the three others (fig. 7). This is the young embryo-sac.

A curious anomaly is here worth recording. In one ovule which had passed the fertilization-stage, and in whose embryo-sac the two polar nuclei had already fused to form the definitive nucleus, two of the sister-cells of the embryo-sac had persisted, but were both very much smaller than, and partly distorted by, the latter. The cell adjoining the embryo-sac contained four nuclei, all closely in contact with each other and containing conspicuous nucleoli. The other cell exhibited but a single nucleus to view. Of the many hundreds of ovules examined, this was the only one which showed this irregularity (Pl. XX. fig. 15).

There is variation in different ovules as to the length which the incipient embryo-sac may attain before division of the primary nucleus takes place. In some it may grow to a considerable length, in others remain quite short.

Shortly before division the nucleus appears greatly swollen and curiously vacuolated; but this may be simply due to the method of treatment which the ovules have undergone prior to their being sectioned, so that there is probably no importance to be attached to these appearances (figs. 9–12).

At the next stage two nuclei are seen, resulting from the division of the first one at each end of the sac (figs. 11, 12). Each of these divides again, so that now two nuclei are present at either end of the sac. I missed seeing this particular stage, the nearest approach to it being an embryo-sac with a single nucleus at one end and a nuclear spindle at the other (fig. 13). I also failed to obtain any section, exhibiting the next stage to this, where each of the two nuclei at either end divide again, so that four nuclei are formed at each extremity of the embryo-sac.

The stage most commonly met with, and of which there was most material at hand, was that in which the egg-apparatus appeared fully formed and differentiated at the micropylar end. Here were usually seen two large elongated synergidæ, each containing, either halfway down or towards its upper end, a conspicuous nucleus of considerable size, while the lower broader end was occupied by a vacuole. The tapering extremities of these cells disappeared in the upper end of the embryo-sac (figs. 14–18). A third nucleus, equal in size to those of the synergidæ, and likewise surrounded by a membrane of protoplasm, occurred either at the lower end of these or lying on the top of or beneath them in a different plane of the section: this is the ovum (figs. 14, 17, 18, *ov*). Owing to the fact of its often

lying in a different plane, this nucleus is frequently cut away in sections which show the synergidæ. In the majority of cases there were also two additional nuclei shown lying either in close proximity to each other or separated by a little space, each being equal in size to the nucleus just described. These are the *two polar nuclei.* In position they were either quite close to the egg-apparatus or some distance away from it (Pls. XX., XXI. figs. 14–17, 19, 20 *b*, *pn*). Very various were the positions observed to be taken up by these two nuclei with regard to each other. Most frequently they might be seen in close connexion, and this connexion was observed, in a transitional series of cases to result from, at first, a slight contact at one point to the most complete fusion, during which the common wall of the two nuclei gradually became absorbed, the two nucleoli fused into one, and a single deep-coloured and very conspicuous nucleus was formed, double the size of the two original ones. This is the secondary or definitive nucleus (figs. 18, 21, 22, *dn*).

In a few instances a deep-coloured elongated mass, which may possibly represent part of a pollen-tube, appeared above or between the two synergidæ (figs. 19, 21, *pt*).

As regards the chalazal end of the embryo-sac at this stage of the development, in the rare cases where it was clearly exposed to view three distinct antipodal cells were seen to be present (figs. 14 & 15, *ant*). Two of these, lying side by side and occupying the extremity of the sac, were slightly elongated, and in shape rather like the synergidæ, but in size they were very much smaller than the latter. The third cell, somewhat similar in shape to the ovum, lay in contact with their upper ends. Very often but two antipodal cells were visible. Owing to the obliquely lying position of the ovules in the ovary, the embryo-sac was but rarely cut medianly through from one end to the other, and thus usually the micropylar end was seen in one section, and the antipodal end in another section of the same ovule. Fig. 14, however, was made from a single section. At a certain stage in the development of the ovule, of which much fewer preparations were obtained, the ovum begins to form the young embryo. At the youngest stage the latter resembles somewhat one of the synergidæ, at whose side it grew out as an elongated cell, swollen at its anterior end, and tapering at the other by a very narrow prolongation towards the micropylar region. It could

usually, however, be distinguished from a synergid by the fact that its nucleus lay always at the extreme anterior tip of the cell. As the young embryo thus grows out the synergidæ become considerably deranged and eventually disintegrated (Pl. XXI. figs. 19, 20 *a*, 20 *b*, 21, 22). The process of fertilization of the ovum was not observed; and the only cases where the presence of a pollen-tube could be at all surmised are those given above. Figs. 19 and 20 *b* afford instances where the development of the embryo may begin before fusion of the polar nuclei has taken place.

As a result of the division of the definitive nucleus, the narrow embryo-sac becomes filled with a row of four elongated cells. Koch, in his description of the initial formation of the endosperm in *Orobanche*, states that at first several nuclei are formed, between which, after they are evenly distributed in the sac, cell-walls are intercalated. This will also probably be the course of events in *Christisonia*, although in this plant I have been unable to follow it. Subsequently, by longitudinal and transverse divisions in the cells, the embryo-sac becomes very much enlarged and swollen out, a large endosperm-tissue being produced. At each end, however, the sac remains as a narrow prolongation which is devoid of endosperm-tissue, enclosed by the layers of the nucellus.

The further development of the young embryo was not clearly observed until the endosperm had undergone several divisions. It was as yet undivided, though greatly elongated, with an aggregation of dense protoplasm, containing a nucleus, at its anterior extremity (fig. 23). The subsequent development would seem to be exactly as Koch has described it, although I have not in these plants been able, as he was in *Orobanche*, to follow all the successive divisions which go to form the mature embryo. The reason for this is that, in the first place, the divisions which take place appear to be more irregular than they are in the latter plant; and, secondly, that in *Orobanche* the whole structure is much clearer and better defined, owing to the absence of the purple coloration which in *Christisonia* is such a bane to the observer.

The next stage in the development of the embryo is that in which a transverse wall divides it into two cells, an anterior swollen cell and the suspensor (fig. 24). Soon after the latter loses its protoplasmic contents and becomes henceforth colourless.

Further transverse divisions would then appear to occur in the upper portion, by which this part becomes much elongated, and, contrary to what is described for *Orobanche*, much greater in length than in breadth (Pl. XXI. figs. 25, 26). About this time also longitudinal divisions occur in two directions (figs. 26–29).

There does not seem to be in these plants such a clear delimitation of the hypophysis from the rest of the embryo as is afforded by *Orobanche*; but in some embryos its position was, nevertheless, fairly easy to trace, as in figs. 31–35, *h*. It is doubtless separated off by the first transverse wall which is formed in this part of the embryo. It subsequently becomes divided into two parts by another transverse wall. A longitudinal wall is then formed in each of these cells. Eventually the lower portion of the hypophysis, consisting of two small narrow cells, becomes destroyed, while the upper portion becomes divided up into several cells by longitudinal walls. About the time that the longitudinal wall occurs in the hypophysis the dermatogen begins to be cut off in the upper part of the embryo, the first walls appearing in the lower portion of this part (fig. 30). The number of the cells of the dermatogen is increased by anticlinal divisions. Numerous divisions then occur in the interior of the embryo, by which it becomes greatly increased in size, so that it at length comes to assume somewhat of an oval or even semi-orbicular shape (figs. 31–37).

The developmental structure of the embryo of *Christisonia* is, therefore, in its main features similar to that of the embryo of *Orobanche* as described by Koch. It differs in its minor details from that of the latter in being apparently rather more rudimentary, and in the different parts being less sharply defined. This would agree with what we know of the vegetative structure of the adult plant, which certainly is more reduced and more rudimentary than that of *Orobanche*; and thus it is not surprising if in the embryonic condition of the plant a more reduced structure is also met with.

We have seen, however, that the development of the ovule is essentially similar at every stage to that of the ovule in *Orobanche*.

The main part of this investigation was carried out in the botanical laboratory of the Royal College of Science, South Kensington. It was eventually finished and completed in the

Jodrell Laboratory, Royal Gardens, Kew. I have to thank Prof. J. B. Farmer, who brought the material from India and Ceylon, for continual assistance and the many kind suggestions which he has afforded me during my work.

EXPLANATION OF THE PLATES.

ar=archesporium; *es*=embryo-sac; *nc*=nucellus; *syn*=synergidæ; *ov*=ovum; *pn*=polar nuclei; *ant*=antipodal cells; es^1, es^2=sister-cells of embryo-sac; *pt*=pollen-tube; *dn*=definitive nucleus; *emb*=embryo; *end*=endosperm *t*=testa; *d*=dermatogen; *h*=hypophysis; *s*=suspensor.

Plate XX.

Fig. 1. Longitudinal section of a young ovule of *Christisonia neilgherrica*, Gardn., showing the archesporium. ×520.

Fig. 2. The same at a rather later stage. ×520.

Fig. 3. Longitudinal section of a young ovule of *C. subacaulis*, Gardn., showing a double archesporium. ×520.

Fig. 4. Enlarged archesporium of *C. neilgherrica*, Gardn., showing division of its nucleus. ×520.

Fig. 5. Archesporium of *C. neilgherrica*, Gardn., showing its division into two cells. ×520.

Fig. 6. Archesporium of *C. neilgherrica*, Gardn., showing its division into four cells. ×520.

Fig. 7. A somewhat later stage of the same, showing the developing embryo-sac. ×520.

Fig. 8. Two young embryo-sacs in a single ovule of *C. neilgherrica*, Gardn., of which one is becoming crushed. ×520.

Figs. 9 & 10. Young embryo-sacs of *C. subacaulis*, Gardn., before division of the primary nucleus. ×520.

Figs. 11 & 12. The same after division of the primary nucleus. ×520.

Fig. 13. The same, with the nucleus at one end undergoing division. ×520.

Fig. 14. Mature embryo-sac of *C. neilgherrica*, Gardn., showing the egg-apparatus, polar nuclei, and antipodal cells. ×520.

Fig. 15. Mature embryo-sac of *C. neilgherrica*, Gardn., with two persistent sister-cells at the micropylar end. ×520.

Plate XXI.

Figs. 16–18. Upper portion of the embryo-sac of *C. neilgherrica*, Gardn., before development of the embryo. ×520.

Fig. 19. The same, showing the embryo beginning to grow out; only one of the synergidæ is shown. ×520.

Figs. 20 *a* & 20 *b*. Upper portion of the embryo-sac of *C. subacaulis*, Gardn., the embryo beginning to grow out. ×520.

Fig. 21. Upper portion of the embryo-sac of *C. neilgherrica*, Gardn., with the embryo beginning to grow out. ×340.

Fig. 22. The same. ×520.

Fig. 23. Longitudinal section of the endosperm of *C. subacaulis*, Gardn., showing the developing embryo. ×520.

Fig. 24. Section of a young two-celled embryo of *C. subacaulis*, Gardn. ×350.

Fig. 25. An embryo of the same with two transverse divisions in its upper cell. ×350.

Fig. 26. An older stage of the same with several transverse and one or two longitudinal divisions in the upper cell. ×350.

PLATE XXII.

Fig. 27. Transverse section of a seed of *C. subacaulis*, Gardn., showing the different parts, from the testa on the outside to the embryo in the centre. ×100.

Figs. 28 & 29. Transverse sections of embryos of *C. subacaulis*, Gardn., showing the longitudinal walls in two directions. ×420.

Figs. 30–38. Further stages in the differentiation of the various parts of the embryo of *C. subacaulis*, Gardn.

Figs. 31, 32, 36, 38: ×390. Figs. 30, 33, 34, 35, 37: ×420.

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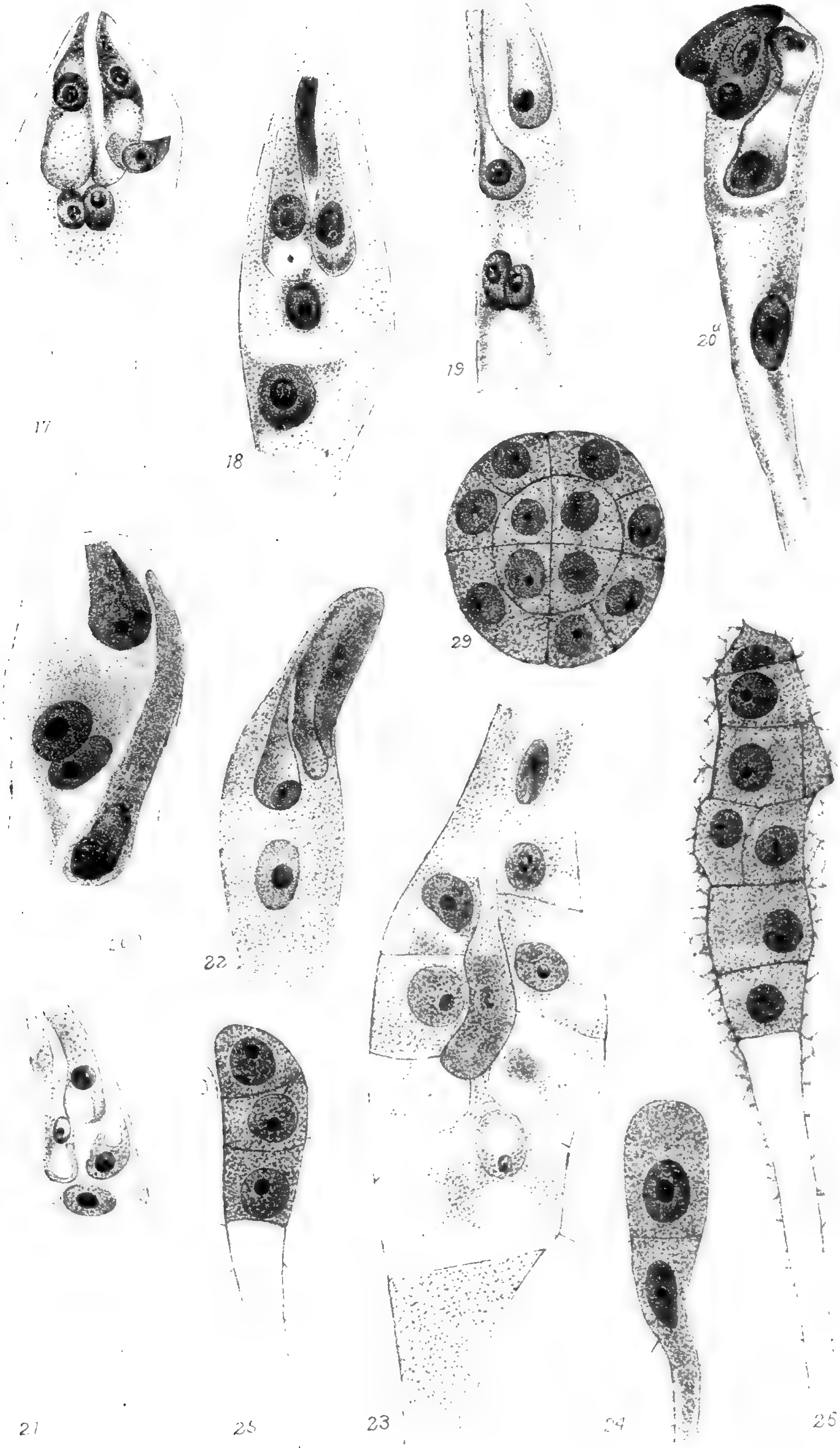
A.R. Hammond lith.

Hanhart imp.

OVULE OF CHRISTISONIA.



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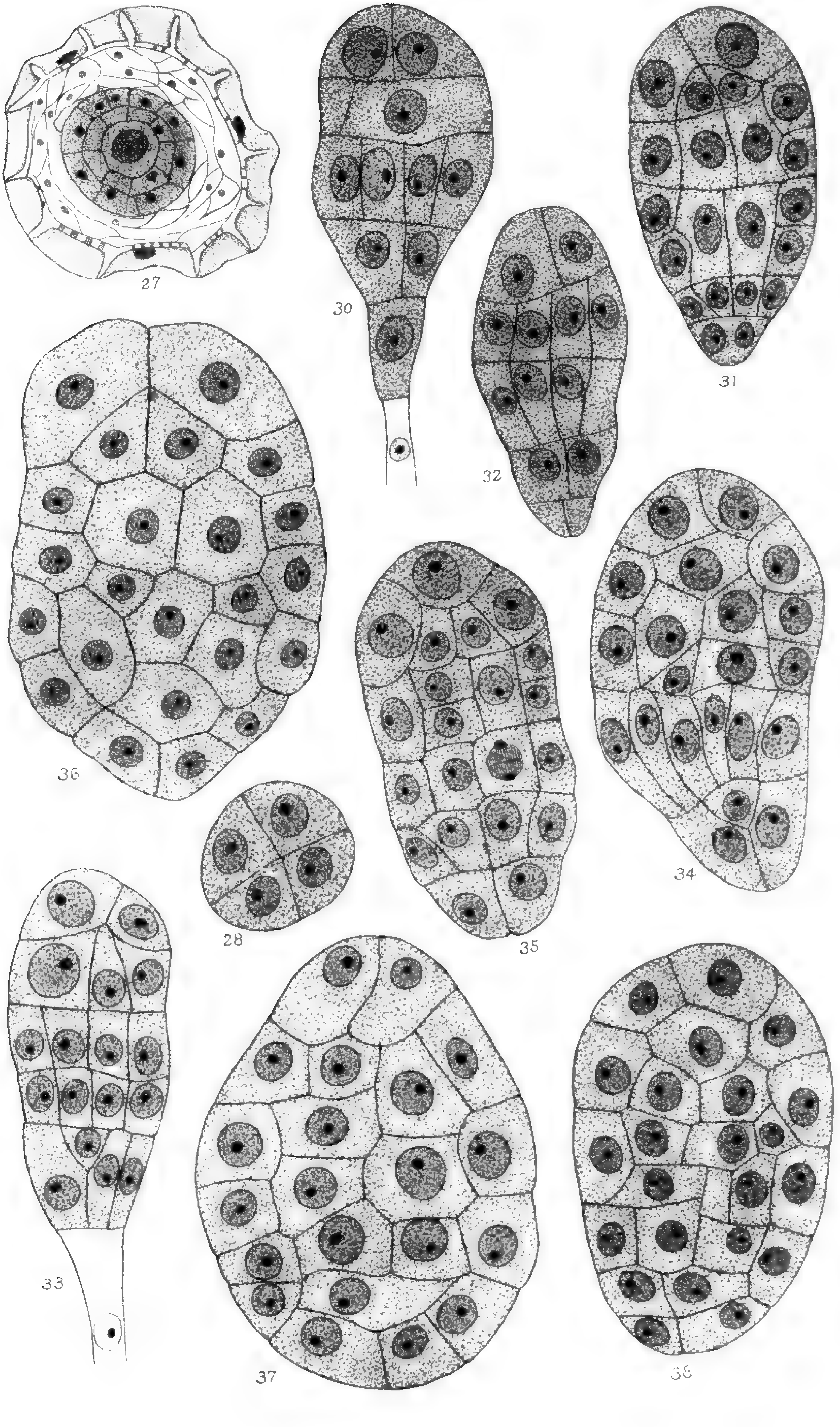

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OVULE OF CHRISTISONIA

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[Synonyms and native names are printed in *italics*. A star is added to names which are ostensibly here published for the first time.]

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(Nos. 178–180 are reserved for the continuation of Messrs. Forbes and Hemsley's 'Index Floræ Sinensis.')

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